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Research Article

Effect of Dietary Replacement of Maize with Finger Millet (*Eleusine coracana*) Grain on Production Performance and Egg Quality of White Leghorn Hens

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Abstract

Objective: A study was conducted to evaluate the effect of replacing maize by finger millet as energy source on feed intake, body weight gain, egg production and quality parameters of white leghorn layers. **Materials and Methods:** One hundred and eighty chickens were randomly distributed in 5 treatments, each replicated three times with ten layers and two cockerels/replicate in CRD and kept on a deep litter system. The treatment rations were formulated to contain finger millet in place of maize at the rate of 0 (T1), 25 (T2), 50 (T3), 75 (T4) and 100% (T5). Birds were offered a weighed amount of feed and feed leftover was collected and weighed the next morning. Weight of chicks was taken at the beginning and end of the experiment. Egg production and egg quality parameters were also recorded. **Results:** Finger millet contained 9% crude protein (CP) and 3280 kcal kg^{-1} metabolizable energy (ME) on DM basis. Dry matter intake among T1, T2, T3, T4 and T5 (94, 91, 94, 95 and 90 g/hen/day, respectively) was not different ($p>0.05$). There were significant differences ($p<0.05$) among treatments in percent hen day egg production (33.09, 34.62, 36.89, 39 and 31.96, SEM = 2.735) for T1, T2, T3, T4 and T5, respectively. Significant differences ($p<0.05$) among treatment groups was observed in albumen weight, shell weight and shell thickness but no significant differences ($p>0.05$) in yolk weight, yolk height, albumen height and haugh unit was noticed. Albumen weights of 28.2, 28.9, 29.8, 29.99 and 31 g were recorded respectively for T1, T2, T3, T4 and T5. The egg shell thickness were also 0.263, 0.298, 0.304, 0.334 and 0.314 μm for T1, T2, T3, T4 and T5, respectively. Roche color fan reading revealed that eggs from hens fed T1 diet had significantly ($p<0.01$) lighter yellow yolk color (1.66) than T2 (2.428), T3 (2.76), T4 (3.43) and T5 (3.33). **Conclusion:** Increasing dietary level of finger millet grain in layer ration has no negative impact on production performance, quality parameters of eggs and thus finger millet can completely replace maize in layers ration. Further, substitution of maize with finger millet grain up to 75% was found profitable because of the increased egg production.

Key words: Finger millet, egg production, egg quality, feed intake, leghorn layers

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Animal production in general and chickens in particular play important socio-economic roles in developing countries[1,2]. Provision of animal protein, generation of extra cash incomes and cultural considerations are amongst the major reasons for keeping village chickens by rural communities[3]. Poultry production is an important economic activity in Ethiopia[4]. Both poultry egg and meat enrich and contribute to a well balanced diet to satisfy human needs. The total population of chicken in Ethiopia is about 50.38 million comprising cocks, cockerels, pullets, laying hens, non-laying hens and chicks[5].

Nutrition is perhaps the most important consideration in livestock management. Inadequate supply of feeds, nutritionally unbalanced rations, adulterated ingredients or stale feeds are some of the factors responsible for low productivity of livestock in tropics[6]. The major cost of production of egg and meat in commercial poultry production is feed. Feed cost can be 55-75% of the total production expenses depending on the geographical location, season and country[7]. In response to this, researches conducted in Ethiopia also focused, among other things on determining the feeding value of locally available feed resources, comparative economic and biological evaluation of different feed resources and assessment of the values of various feed ingredients and supplements in improving product quality[8]. However, further effort in this line is becoming evident as a result of changing conditions and a need for widening the range of the possible feed ingredients. This is particularly important in Ethiopia since the availability and cost of feed is one of the major limitations to poultry production because of the fact that there is shortage of cereal grains, protein sources, vitamins and mineral supplements required to formulate balanced poultry rations, which are further aggravated by the competition between poultry and human for food and the upcoming alternative uses of major feed ingredients of poultry, such as maize.

Maize is the major feed ingredient in broiler and layers ration with the inclusion level of up to 60%. Maize is also used for other purposes such as bio-fuel, brewing, starch industries and for human consumption. However, inadequate production of this grain and the intense competition for maize between man, industries and livestock especially in the drier areas of the tropics has made poultry rations to be expensive[9] and a wider gap occurs between supply and demand.

Therefore, it is essential to identify and evaluate less expensive, readily and locally available energy source for poultry feeding in the place of maize. Finger millet is one of the most drought-tolerant of all domesticated cereals[10] making it the only reliable productive cereal in the driest rain-fed regions of the arid and semi-arid tropics. It grows mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields[11]. The cultivation of this crop is relatively easy and it has been found to be reliable under circumstances where other cereal crops would have failed due to drought or would have given negligible yield. The major attributes of finger millet are therefore, its adaptability to adverse agro-ecological conditions with minimal inputs, tolerant to moisture stress, produced on marginal land where other crops cannot perform and tolerant to acidic soil and termite.

Grain yields are variable, but are generally good. A threshed yield of 1,800 kg ha^{-1} is regarded as average. On reasonable dry land sites, yields may run to about 1,000 kg ha^{-1} and on irrigated sites a normal average is more than 2,000 kg ha^{-1}. Yields of 5,000-6,000 kg ha^{-1} have been obtained under ideal irrigated conditions[12]. Finger millet has high nutritional value and excellent storage qualities[13]. It has high content of calcium (0.38%), dietary fiber (18%) and phenolic compound (0.03-3%). Total carbohydrate content of finger millet has been reported to be in the range of 72-79.5%[14]. It has a large variations (5.6-12.70%) in protein content[14]. The crude fat content in finger millet has been reported in range of 1.3-1.8%[15]. Total ash content is higher in finger millet than in commonly consumed cereal grains. Finger millet has been widely neglected by both researchers and policy makers in the past decades. While maize is growing well under favorable agro-ecological conditions, millets are much better adapted to poor soils, high temperatures and erratic rainfall and can therefore play an important role in improving food[16]. Frustrated by repeated failure of the maize crop as a result of frequent drought and soil fertility degradation, a growing number of farmers in the dry rift valley region of Ethiopia widely adopted cultivation of finger millet[17,18]. Over the past two decades in Ethiopia, the area for finger millet cultivation increased by about 145% while the yields nearly doubled during the same period[19]. It is currently grown on more than 431,506 ha, which accounts 4.48% lands allocated for cereals and 742,297 t is harvested with an average yield 1.507 t ha^{-1} [5] and accounts 4% of the total cereal yield annually[20]. Different researches have been made to evaluate the feeding value of raw whole finger millet for poultry and most studies[21-23] noted that as the level of finger millet increased in the diet, feed intake and body weight and egg production depressed. This might be due to the fact that finger millet has different antinutrients which can limit feed intake and its bioavailability to animals. Efforts to use finger millet as feed should be continued by employing different processing techniques that can reduce its antinutritional factors and enhance its feeding value. Therefore, this study was aimed to evaluate the replacement value roasted finger millet (*Eleusine coracana*) grain for maize in layer diet.

MATERIALS AND METHODS

Study area: The experiment was conducted at Haramaya University Poultry Farm, which is located at 42°3' East longitude, 9°26' North latitude, at an altitude of 1980 m.a.s.l. and 505 km East of Addis Ababa, the capital city of Ethiopia. The mean annual rainfall of the area amounts to 780 mm and the average minimum and maximum temperatures are 8 and 24°C, respectively[24].

Experimental rations and design: Maize, finger millet (FM), wheat short, soya bean meal (SBM), noug seed cake (NSC), salt, vitamin premix and limestone were used in the experimental rations. SBM and NSC were purchased from Health Care Food Manufacturer PLC, Addis Ababa. Maize, finger millet, wheat short and salt were purchased from the local market of Haramaya and Dire Dawa, vitamin premix from GASCO Trading PLC, Addis Ababa and limestone from Haramaya University. Finger millet was roasted on flat-surfaced clay (Mitad) with an open fire for about 10 min.

Representative samples of individual ingredients were analyzed for chemical composition and accordingly treatment rations were formulated to be isocaloric (2800-2900 kcal ME kg^{-1} DM) and isonitrogenous (16-18% CP) and to meet the layers' nutrient requirements. In T1, T2, T3, T4 and T5: 0, 25, 50, 75 and 100% of maize was replaced by finger millet grain, respectively (Table 1).

About 150 hens and 30 cocks (1092±13 g) were obtained from Haramaya University poultry farm and randomly assigned to 5 groups of 36 birds. Each group was subdivided into 3 replicates of 12 birds (10 hens and 2 cocks) in a completely randomized design (CRD). Each group was randomly assigned to the 5 experimental diets (Table 2).

Experimental animals and management: Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. The birds were fed experimental diets *ad libitum* for 90 days. Health precautions and diseases control measures were taken throughout the experimental period. The birds were kept on full litter housing system. Birds were fed in group and feeds were offered twice a day at 8:00 AM and 4:00 PM throughout the experimental period. Next morning the left over was collected and weighed after removing external contaminants by visual inspection. Water was available at all times. Each pen was equipped with individual laying nests, which were covered with natural pasture hay.

Table 1: Layout of the experiment

Treatments	Rep.	Number of chicken
T1 = Ration containing 100% maize +0% finger millet	3	12
T2 = Ration containing 75% maize +25% finger millet	3	12
T3 = Ration containing 50% maize +50% finger millet	3	12
T4 = Ration containing 25% maize +75% finger millet	3	12
T5 = Ration containing 0% maize + 100% finger millet	3	12

Table 2: Proportion of feed ingredients used in formulating the experimental diets

Ingredients (kg/100 kg)	Treatment diets				
	T1	T2	T3	T4	T5
Maize	45.00	33.75	22.50	11.25	0.00
Finger millet	0.00	11.25	22.50	33.75	45.00
Wheat short	18.00	17.40	18.20	17.80	18.00
Noug seed cake	15.70	16.00	15.40	15.90	15.70
Soya bean meal	13.00	13.20	13.10	13.00	13.00
Limestone	7.00	7.00	7.00	7.00	7.00
Salt	0.50	0.50	0.50	0.50	0.50
Vitamin premix	0.80	0.80	0.80	0.80	0.80
Total	100.00	100.00	100.00	100.00	100.00

Data collection

Feed intake and conversion ratio: For each replicate, the feed offered and refusal was recorded and feed consumed was determined by difference. Feed conversion ratio was determined by dividing total DM consumed (g/hen/day) by unit of egg mass (g/hen/day).

Body weight measurement: Body weights of individual birds were recorded at the start and end of the experiment by using sensitive balance. Mean body weight gain was determined as:

$$\text{Body weight measurement} = \frac{\text{Final body weight} - \text{Intial body weight}}{\text{Number of feeding days} \times \text{Number of experimental chickens}}$$

Egg production and egg quality: Eggs were collected twice a day from each pen in the morning (08:00) and evening (16:00). Eggs were weighed per replicate by using sensitive balance. Laying rate was expressed as the average percentage of hen-day and hen-housed egg production by computing the average values from each replicate using the method of Hunton[25] as follows:

$$\text{Hen-day egg production (\%)} = \frac{\text{Number of eggs collected per day}}{\text{Number of hens present that day}} \times 100$$

$$\text{Hen-housed egg production (\%)} = \frac{\text{Total number of eggs during trial}}{\text{Number of hens originally housed} \times \text{Experimental days}} \times 100$$

Egg mass and internal and external egg quality: To obtain average egg weight per replicate, the sum of weights of all eggs collected from each pen was divided by the number of eggs collected from that pen. Then, the following formula was used to calculate the egg mass on daily bases:

$$\text{Egg mass} = \frac{\text{Average number of eggs / hen} \times \text{Average weight of eggs/replicate}}{\text{Number of hens/replication}}$$

Egg quality parameters were determined at interval of 7 days on freshly laid 3 eggs/replicate. Yolk weight, color and height, albumen weight and height, shell weight and thickness were recorded. Egg shell thickness was measured using micrometer gauge. The measurements were taken from three site, top (pointed part), bottom (round part) and the middle part of the egg. Finally, the average of the three sites was taken as eggshell thickness.

The albumin of the broken egg was carefully separated from the yolk. Tripod micrometer and sensitive balance was used to measure the albumin height and weight, respectively. Haugh unit is the most sensitive and widely used measurement method of albumin quality. It is an expression that depends on eggs weight and height of thick albumin. The calculated value and table value of haugh unit was compared to determine the quality of the albumin. The haugh unit was calculated using the following equaiton[26]:

$$\text{Haugh unit (HU)} = 100 \log\left[\text{H-G}\left(\frac{30 \text{ W } 0.37\text{-}100}{100}\right)+1.9\right]$$

Where:

HU = Haugh unit (g)
G = Gravitational constant, 32.2
H = Albumin height (mm)
W = Weight of egg

After separation of the yolk and albumin, yolk height was measured by tripod micrometer and yolk weight was taken by using sensitive balance. After taking the height and weight, the yolk was shacked thoroughly to mix its contents. Then sample was taken on a piece of white paper and yolk color was determined by comparing the yolk color with Roche color fan measurement strips, which consist 1-15 strips that ranges from pale to deep yellow color.

Chemical analysis: Chemical analysis of feed ingredients and dietary treatments used for the three experiments were undertaken. Representative samples were taken from each feed ingredients and analyzed before formulating the actual dietary treatments and the result was used for formulation of the experimental diets for all experiments. Samples were also taken from each treatment/experimental rations at each mixing and kept in paper bags until analysis. All samples were analyzed for dry matter (DM), nitrogen (N), fat or ether extract (EE), crude fiber (CF), ash, calcium and phosphorus at Haramaya University Nutrition and Central Laboratories following the proximate analysis method of AOAC[27]. Nitrogen was determined by Kjeldahl procedure and crude protein was calculated as N×6.25. Metabolizable energy contents were determined by indirect methods described by Larbier *et al.*[28] as follows:

$$\text{ME (kcal kg}^{-1}\text{ DM)} = 3951+54.4\text{EE}-88.7\text{CF}-40.8\text{ Ash}$$

Economic analysis: Cost-benefit analysis for layers on diets containing different substitution levels of finger millet for maize was undertaken according to the principles developed by Upton[29]. Prices of feed, labour and eggs were used for calculation. The net income (NI) was calculated by subtracting total variable cost from the total return (TR) as: NI = TR-TVC.

The change in net income (ΔNI) was calculated as the difference between the changes in total return (ΔTR) and change in total variable cost (ΔTVC) as: ΔTR-ΔTVC. The marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC): MRR = ΔNI/ΔTVC×100. Egg sale price to feed cost ratio was also calculated as additional parameter to evaluate the efficiency of the change in feed ingredients.

Efficiency of feed to produce a given number of eggs and egg to feed ratio was calculated by employing the following equation:

$$\text{Eggs sale to feed cost ratio} = \frac{\text{Total eggs sale (Birr) or}}{\text{Total feed cost (Birr)}}$$

$$\text{Feed cost to eggs sale ratio} = \frac{\text{Feed cost (Birr/egg) or/feed}}{\text{Egg sale (Birr/egg)}}$$

Statistical analysis: All the data collected by this study was subjected to statistical analysis using the SAS version 9 computer software. When the analysis of variance revealed the existence of significant differences among the dietary treatments, means were separated using least significant difference (LSD). The following model was used to analyze data:

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

Where:

Y_{ij} = An observation (response variable)
μ = Overall means
T_i = Treatment effect of ith treatment and
e_{ij} = Error term[30]

RESULTS AND DISCUSSION

Chemical composition of experimental feeds: The chemical composition of feed ingredients used and the five dietary treatment rations are shown in Table 3 and 4, respectively. On the contrary to this study Gunashree *et al*.[31] reported lower (6.8%) while Ibe[32] reported higher (12.14%) CP contents for finger millet. The total fat, crude fiber and ash contents of finger millet were reported to be 1.8, 3.17 and 2.0%[31].

The CP and ME contents of the experimental diets were approximately within (Table 4) the recommended range. The recommended range of CP and ME is 16-17% and 2800-2900 kcal kg^{-1}, respectively for layers[33].

Feed intake and body weight change: The effect of replacing maize by finger millet in layers' ration on dry matter intake (DMI) and body weight gain (BWG) is presented in Table 5. There was no significant difference in DMI of birds fed on the different diets. Similar DMI (93.1-94.5 g/hen/day) for white leghorn chickens fed on graded levels of dried cafeteria food leftover was reported by Tamasgen[34]. Compared to the current experiment, Kebede[35] reported higher level of DMI (131-135 g/hen/day) for white leghorn layers fed with diets containing different levels of malted barley grain as a substitute for maize.

Table 3: Chemical composition of feed ingredients used for preparation of experimental diets

	Feed ingredients				
Parameters	Maize	Finger millet	Wheat short	Noug seed cake	Soya bean meal
DM (%)	90.90	94.00	91.00	92.00	92.80
CP (% DM)	8.80	9.00	15.20	31.20	37.60
EE (% DM)	5.10	6.00	5.00	5.00	8.40
Ash (% DM)	3.80	3.20	4.78	8.00	7.50
CF (% DM)	4.60	4.00	8.00	17.20	6.10
Ca (% DM)	0.03	0.42	0.12	0.20	0.30
P (% DM)	0.30	0.38	0.41	0.31	0.70
ME (kcal kg^{-1})	3665.40	3792.00	3318.40	2370.96	3560.89

DM: Dry mater, CP: Crude protein, EE: Ether extract, CF: Crude fiber, Ca: Calcium, P: Phosphorus, ME: Metabolizable energy, kcal: Kilo calorie, kg: Kilogram

Table 4: Chemical composition of treatment diets containing different proportions of maize and finger millet

	Treatment diets				
Parameters	T1	T2	T3	T4	T5
DM (%)	90.00	91.30	92.00	91.80	93.00
CP (% DM)	16.48	16.60	16.50	16.58	16.57
EE (% DM)	5.07	5.17	5.30	5.47	5.58
Ash (% DM)	4.80	4.67	4.55	4.44	4.30
CF (% DM)	7.14	6.74	6.90	6.85	6.70
Ca (% DM)	3.10	3.30	3.20	3.28	3.31
P (% DM)	0.30	0.40	0.40	0.41	0.43
ME (kcal kg^{-1})	3397.65	3443.87	3441.65	3459.82	3484.82

DM: Dry mater, CP: Crude protein, EE: Ether extract, CF: Crude fiber, Ca: Calcium, P: Phosphorus, ME: Metabolizable energy, kcal: Kilo calorie, kg: Kilogram, T1-T5 = Treatments

Table 5: Feed intake and body weight changes of white leghorn layers fed on different experimental diets

	Treatments						
Feed intake and body weight	T1	T2	T3	T4	T5	SL	SEM
Initial BW (g/pen)	1128	1127	1129	1126	1128	NS	3.473
Final BW (g/pen)	1176	1177	1178	1167	1178	NS	33.06
BW Gain (g/pen)	48	50	49	41	50	NS	2.859
TDMC (g/pen)	93253^{a}	88472^{bc}	90104^{ab}	94021^{a}	87582^{c}	**	2238
TDMC (g/hen)	8478	8216	8461	8547	7864	NS	453
DDMI(g/hen/day)	94	91	94	95	90	NS	453.4
FCR	6.34^{bc}	6.70^{ab}	7.22^{a}	5.15^{d}	5.82^{cd}	***	0.39

^{a,b,c,d}Means with in a row with different superscripts are significantly different, **Significant at (p<0.01), ***Significant at (p<0.001) NS: Non-significant (p>0.05), SL: Significant level, SEM: Standard error of mean, TDMC: Total dry matter consumed, g: gram, BW: Body weight, FCR: Feed conversion ratio, T1-T5 = Treatments

Table 6: Egg production, egg weight and egg mass performance of white leghorn layers fed with different proportion of finger millet as a replacement for maize

Parameters	Treatments						
	T1	T2	T3	T4	T5	SL	SEM
Birds/pen	12	12	12	12	12	NS	5.30
Egg yield/pen	328[bc]	332[bc]	353[b]	387[a]	306[c]	***	18.28
Total egg/hen	33[b]	28[c]	28[c]	39[a]	31[bc]	***	2.19
HDEP (%)	33.09[b]	34.6[ab]	36.9[ab]	39.09[a]	31.96[b]	*	2.73
HHEP (%)	33.09[bc]	33.5[bc]	35.65[b]	39.09[a]	30.87[c]	**	1.85
Egg weight (g)	44.9	463	45.5	45.5	46.4	NS	1.16
Egg mass (g/pen)	16.4	14.5	13.9	20.3	16.1	NS	1.17

[a,b,c]Means with in a row with different superscripts are significantly different, **Significant at ($p<0.01$), ***Significant at ($p<0.001$) NS: Non-significant ($p>0.05$), SL: Significant level, SEM: Standard error of mean, HDEP: Hen day egg production, g: gram, T1-T5 = Treatments

Contrary to the current results Alemayehu *et al.*[36] reported lower level of DMI (88-90 g/hen/day) for hens fed with different proportion of fish waste meal. Afolayan *et al.*[37] noted no significant differences in the consumption of the experimental diets when maize was replaced by sweet potato meal up to 40%.

Both the initial, final body weight and body weight gain of layers, fed diets containing varying levels of finger millet as a substitute for maize, did not show any significant difference($p>0.05$) between treatments. Kebede[35] reported similar body weight gains for white leghorn layers fed with different levels of malted barley grain as a substitute for maize. Contrary to this finding, higher level of body weight gains (205-244 g/hen) were noted by Taye[38] for hens fed with graded levels of quality protein maize and normal maize. Raphael *et al.*[39] also reported higher body weight gains (1206 g) when 33% of maize was replaced by cassava root meal compared to the control (0% cassava root meal) and live body weight decreased as the substitutional levels of maize with cassava increased in the diets. Positive responses in weight gain and final weight of hens were noted when 20% of maize was substituted by sweet potato[37].

Egg production: The effect of replacing maize with finger millet grain in layers diet on egg production is presented in Table 6. The mean total egg production of birds fed the 5 experimental diets was significantly ($p<0.05$) different among each other across the feeding period. The highest hen day egg production and hen housed egg production value was recorded for the treatments that showed the best feed consumption, while the lowest value was recorded for the treatments that showed the lowest feed intake. Total egg yield and hen day egg production was significantly higher in T4 compared with other treatments. There is no significant difference ($p>0.05$) in egg yield between T1, T2 and T3. Slightly lower egg production was observed in hens fed on T5 compared with those fed on T1, T2 and T3. Ebadi *et al.*[40] reported that replacing 50% of maize grain with sorghum grain increased egg production confirming that there is possibility of replacing maize with other cereal grains as an energy source after appropriate processing. Higher level of egg yield per hen (38-44) was reported for layers fed with different proportion of fish waste meal[36]. Taye[38] reported higher level of egg yield (668-760) and egg weight (50-52 g) for hen fed with different proportions of quality protein maize and normal maize.

Similarly, Mussa *et al.*[41] reported higher level of hen day egg production percent (64-73%) for Lohman white hens fed diets containing different levels of local brewery by-product (Tela-atella). The replacement of maize with cassava in the diet as energy source did not induce any significant negative effect on feed/dozen eggs, egg production cost, egg weight, hen age at first laying and egg mass per hen[39]. Contrary to the findings in the current study Akinola *et al.*[42] reported an increase in egg production as the level of cassava meal increased in the layers diets. Sittiya and Yamauchi[43] reported that feeding whole grain paddy rice to laying hens as a replacement for maize resulted in a similar production performance to that of those fed basal diets, which demonstrated that whole grain paddy rice can be safely replaced up to 100% by corn in the laying hen diets. Higher than the results in the present study Mussa *et al.*[41] reported 40-52 hen housed egg production and 45-58 hen day egg productions for Lohman white hens fed diets containing four levels of local brewery by-product (Tela-atella). The effect of replacing maize with finger millet grain in layers ration on hen-day egg production is presented in Fig. 1.

Egg weight and egg mass: The effect of replacing finger millet grain for maize in layers' ration on egg weight and egg mass is presented in Table 6. There was no significant ($p>0.05$) difference in egg weight and egg mass produced by hens fed the treatment diets. Kebede[35] also reported absence of significant ($p>0.05$) difference in egg weight and egg mass as

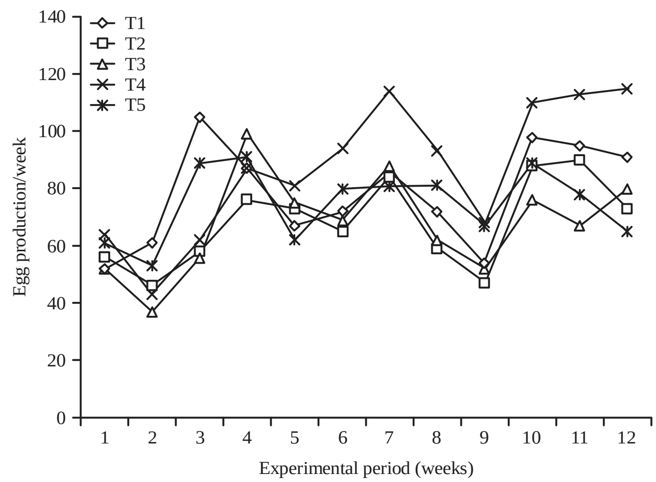

Fig. 1: Weekly average egg production of white leghorn chicken fed diet containing different levels of finger millet grain as a substitute for maize

Table 7: Egg quality parameters of white leghorn chicken fed rations containing different proportions of finger millet grain as a replacement for maize

	Treatment diets						
Parameters	T1	T2	T3	T4	T5	SL	SEM
Shell weight (g)	5.40^{b}	5.80^{a}	5.80^{a}	5.80^{a}	5.90^{a}	**	0.13
Shell thickness (µm)	0.26^{c}	0.30^{b}	0.30^{ab}	0.33^{a}	0.31^{ab}	**	0.02
Albumen weight (g)	28.20^{bc}	28.90^{bc}	29.80^{ab}	30.00^{ab}	31.20^{a}	**	0.95
Albumen height (mm)	7.89	8.42	8.35	8.069	8.38	NS	0.30
Haugh unit	86.57	89.09	88.78	87.47	88.95	NS	1.46
Yolk color (RSP)	1.66^{c}	2.43^{b}	2.76^{b}	3.43^{a}	3.33^{a}	***	0.28
Yolk weight (g)	13.98	14.69	14.30	13.90	14.05	NS	0.56
Yolk height (µm)	14.72	15.24	15.12	15.11	14.85	NS	0.43

^{a,b,c}Means with in a row with different superscripts are significantly different, **Significant at (p<0.01), ***Significant at (p<0.001) NS: Non-significant (p>0.05), SL: Significant level, NS: Non significant, SEM: Standard error of mean, g: gram, T1-T5 = Treatments

malted barley proportion for substitution of maize increased in white leghorn layers diet. Tamasgen[34] noted higher level of egg weight (51-52 g) compared with the current study. Ebadi *et al.*[40] on the other hand reported that replacement of maize with sorghum grain increases egg weight. According to Singh *et al.*[44], different level of inclusion of pearl millet in place of maize (25, 50 and 75%) in the diet of layers resulted in no significant difference in hen-day egg production, egg mass and egg weight. Akinola and Oruwari[42] reported an increase in egg production as the level of cassava meal increased in the layers diets. Raphael *et al.*[39] reported that total replacement of maize with cassava meal in the diet did not negatively affect the egg size. Aderemi *et al.*[45] and Anaeto and Adighibe[46] noted that cassava meal inclusion level above 50% reduced egg production and egg weight.

Egg quality parameters

Eggshell thickness: The mean egg shell thickness, as a measure of egg shell quality, resulting from feeding the 5 treatment rations is shown in Table 7. Egg shell thickness was significantly (p<0.01) different among treatments. The difference in egg weight and egg shell weight among the dietary treatments might have contributed to difference in egg shell thickness. An increase in shell thickness was observed with increased level of finger millet in the diets. Tamasgen[34] reported increased egg shell thickness with increasing level of dried cafeteria food Leftover in layers' diet. Contrary to this, Ebadi *et al.*[40] reported a significant decrease in shell thickness as a result of replacement of maize with sorghum grain in layers. Cho *et al.*[47] also stated that increasing dried food leftover decreases egg shell thickness. The results of this study entails that feeding layers with diets containing different proportions of finger millet grain and maize improved egg shell quality of chicken. The egg shell thickness for treatments T3, T4 and T5 is comparable with the findings of Senayt[48], who reported 0.3 mm (egg shell thickness) for white leghorn chickens fed different proportion of soybean meal. Mahdavi *et al.*[49] reported absence of significant differences in shell thickness between treatments when different levels of barley supplemented with probiotic substituted maize up to 100%. Mean shell thickness of eggs produced by birds fed on 0, 10, 20, 30 and 40% sweet potato meals as a replacement for maize in layers' diet resulted in 0.36, 0.36, 0.36, 0.36 and 0.37 mm egg shell thickness, respectively[37].

Egg shell, albumen and yolk weight: There were significant ($p<0.05$) improvements in shell and albumen weights obtained by replacing maize with finger millet (Table 6). This contradicts with the results reported by Oladunjoye *et al.*[50], who indicated no significant effect on shell, albumen and yolk weight in layers that have consumed diets containing different proportions (up to 80%) of sun dried cassava peel meal. Anaeto and Adighibe[46], on the other hand, revealed significant decrease in shell, albumen and yolk weight as the level of cassava tuber meal increased beyond 50%. Albumen weight was significantly ($p<0.01$) higher in T5 than birds fed diet T1, T2 and T4. Novak *et al.*[51] reported that decreasing amino acid intake significantly decreased albumen weight. In contrast, Salama and El-Sheikh[52] showed that albumen weight, shell weight and shell thickness was not affected but yolk weight was significantly influenced by CP levels. Ebadi *et al.*[40] reported that there was no significant ($p>0.05$) difference in albumen weight, but significant increase in yolk and shell weight as a result of replacement of maize with sorghum grain up to 25% was observed.

Similar to the current study Belete *et al.*[53] reported albumen weight (28-30 g) for white leghorn chicken fed rations containing different levels of processed sholla fruits. On the other hand, Mussa[41] reported higher (31-33 g) albumen weight for Lohman white hens fed diets containing different levels of local brewery by-product (Tela-atella). Kebede[35] also reported similar figures (28-29 g) of albumen weight for hens fed rations containing different levels of malted barley grain as a substitute.

Albumen height and haugh unit: Effects of replacing maize with finger millet in layers diet on albumen height and haugh unit (HU) is presented in Table 7. There is no significant difference ($p>0.05$) in albumen height and HU between treatment feeds. Kebede[35] also reported no significant difference in albumen height as a result of replacement of maize by malted barly grain in layers ration. As HU measures albumen quality, inclusion level of finger millet did not affect this quality. The height of the albumen determines the HU of the egg. The higher the height of the albumen, the greater the numerical value of the HU's and the better the quality of the eggs. But, albumen height did not significantly vary among treatments in the present study. Similarly, Zhai and Zhang[54] noted no significant effect of quality protein maize on egg weight and HU as its inclusion level increases in layers rations. Lower than the results of the current study, Afolayan *et al.*[37] reported 80.44, 79.75, 78.97, 78.31 and 77.03 values of HU for diets containing respectively 0, 10, 20, 30 and 40% of sweet potato meal in the place of maize.

Yolk height and color: Effects of replacing maize with finger millet in layers diet on yolk height and color is presented in Table 7. Substituting maize by finger millet did not bring noticeable change on the yolk height. Yolk color showed significant ($p<0.001$) difference among the different treatments. Taye[38] also reported higher yolk color scores with increasing level of quality protein maize as a replacement for normal maize. Falfiolu *et al.*[55] reported a slightly higher yolk color with increased level of malted sorghum grain up to 30% in substitution for maize. Prabakara *et al.*[56] reported that consumers preferred mostly the eggs with high yolk color intensity. Yolk height of 15-15.7 μm was reported by Belete *et al.*[53] for white leghorn chicken fed rations containing different levels of processed sholla fruits. Tamasgen[34] reported higher (3.7-5.7 RSP) yolk color values for white leg horn chickens fed graded levels of dried cafeteria food leftover.

Economics of replacing maize with finger millet in layers ration: The economic return in terms of partial budget from egg sale and commercial feed costs are presented in Table 8. According to partial budget analysis, hen fed T4 returned a higher total net income, followed by T3, T2, T1 and T5. Feed cost/dozen of eggs decreases as the inclusion level of finger millet grain increased up to 75% (T1-T4) but in T5 (100% finger millet) feed cost/dozen of eggs was high because of lower feed consumption, which resulted in lower egg production performance. Lower feed cost/dozen of eggs (30.9 ETB) recorded when 75% of maize was substituted by finger millet in layers ration (T4). High egg sale/feed cost (1.359 ETB) was noted in T4 compared with all other treatments. Therefore, substitution of maize with finger millet grain up to 75% is profitable because of the increased egg production, although cost of finger millet is similar with maize. Thus, finger millet can be substituted for maize up to 75% economically without affecting body weight, egg production and quality. Higher level of finger millet inclusion (100%) is not profitable because of the reduction in feed intake and decreased in egg production capability of hens. This finding is in agreement with Salami and Odunsi[57] and Anaeto and Adighibe[46], who reported that replacement of maize in the diets of layers with cassava led to reduction in feed cost. The layers used for this

Table 8: Economics of substituting finger millet grain with maize in layers ration

	Treatment diets				
Parameters	T1	T2	T3	T4	T5
Total feed consumed (kg)	279.759	262.416	270.312	282.063	250.746
Feed cost (ETB)	2926.393	2862.788	2925.131	2991.083	2977.692
Labor cost/processing cost	0	50	60	80	110
Total variable cost (ETB)	2926.393	2912.788	2985.131	3071.083	3087.692
Total egg produced (Number)	983	996	1059	1161	917
Total return/gross income (ETB)	3440.5	3486	3706.5	4063.5	3209.5
Net return/net income (ETB)	514.107	573.212	721.369	992.417	121.808
ΔTR		45.5	266	623	-231
ΔTVC	-	-13.605	58.738	144.69	161.299
ΔNR	-	59.105	207.262	478.31	-392.299
MRR	-	-434.436	352.8585	330.5757	-243.212
Feed cost/dozen of egg(ETB)	35.72402	34.49142	33.14596	30.91559	38.96653
Egg sale/feed cost	1.175679	1.217694	1.267123	1.358538	1.077848

ΔTR: Total return, TVC: Total variable cost, NR: Net return, MMR: Marginal rate of return, T1-T5 = Treatments

study were obtained after many generations, which mean they stayed on the farm for long period of time (personal communication). This might be the reason for low level of egg production in all dietary treatment feeds.

CONCLUSION

There were significant differences among treatments in percent hen day egg production, albumen weight, shell weight and shell thickness. No significant differences ($p>0.05$) in yolk weight, yolk height, albumen height and Haugh unit were observed. Substituting maize by finger millet did not bring noticeable change on yolk height. Feed cost/dozen of eggs decreased as the inclusion level of finger millet grain increased up to 75% (T1-T4) but in T5 (100% finger millet) feed cost/dozen of eggs was high because of lower feed consumption, which resulted in lower egg production. Ration containing 75% finger millet (T4) resulted in lower feed cost/dozen of egg (30.9) and high egg sale per feed cost (1.359) compared with all other treatments. Therefore, substitution of maize with finger millet grain up to 75% is profitable because of the increased egg production.

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