Effects of Substituting Maize with Ground Cassava Tuber on Egg Production and Quality of White Leghorn Hens

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Abstract: A study was conducted to evaluate the effects of substituting maize with ground cassava tuber on performances of white leghorn hens. One hundred ninety-five 32 weeks old white leghorn chickens were used to determine egg production, quality and economics performance of layers fed ration containing peeled and sundried cassava tuber meal (PSCTM) at level of 0 (T1, control), 25 (T2), 50 (T3), 75 (T4) and 100% (T5) by replacing maize grain in the control ration. Birds were randomly distributed to five dietary treatments and replicated thrice each with 13 hens and two cocks. The experiment was conducted for 90 consecutive days. Hens were individually weighed at the start and end of the experiment. Data on dry matter intake (DMI), hen day egg production (HDEP), egg mass and egg weight were recorded daily, whereas egg quality parameters were determined weekly. The result of the study revealed that dry matter intake of layers (80.7, 87.5, 80.8, 83.4 and 83.0) was not significantly different (P > 0.05) among the treatments. Average daily body weight gain was significantly higher (P<0.05) for T2 (0.27 gm/bird) compared to the other treatment groups. Feed conversion ratio, percentage hen- day egg production (and egg mass were higher in T3. There was no difference (P>0.05) among treatments on egg quality parameters except yolk color which was higher for T5. Based on the results of this study, T3(50%) replacement of maize by cassava tuber meal appeared to be a diet of good feeding value, more economical or reasonably cheaper ration which can be used as energy supplement in formulation of layers ration without adverse effects on egg laying performance of white leghorn layers.

Keywords: *Cassava tuber, Egg production, Least cost feed, Weight gain*

Introduction

Poultry production is an area of animal agriculture where food production for human beings is relatively fast, initial investment is low and household labor can be used. Poultry production in Ethiopia is an important economic activity. In addition to its social and cultural benefits, it plays a significant role in family nutrition (CSA, 2021). In commercial system, the profit from poultry production can be increased by minimizing feed cost which accounts for more than half of the total cost of production (Wilson and Beyer, 2000). Poultry are monogastric animals that rely on high quality feeds such as maize, wheat and barley for energy (Leeson and Summers, 2005). However, in most parts of the world, particularly in Africa, cereal grains are staple food for human beings. Moreover, these ingredients are expensive and their inclusion in poultry diet in large proportion increases cost per kg of mixed feed which intern increase cost of production (FAO, 2014).

The use of alternative energy feed sources such as cassava is one of the solutions to alleviate feed related problems in poultry production. Cassava (*Manihot esculenta*) is a multipurpose plant originating from South America (Heuzé *et al*., 2012). It belongs to the family *Euphorbiacea*. Cassava is the most widely distributed and cultivated plant in different parts of the lowland tropics. It is the most significant food crops produced in tropical countries as a major source of carbohydrate for the animal as well as human consumption throughout the tropics (McDonald *et al*., 2010). The ability of this species to tolerate drought and to grow under degraded soil conditions are some of the good attributes of the plant (Legg and Fauquet, 2004). In Ethiopia, cassava is grown in almost all parts of the country. But bulk of its production is situated in South, south western and western parts of the country. In Ethiopia, annual average land coverage and productivity are 195,055 hectares and 501,278.5 tons, respectively (Tesfaye *et al*., 2017).

Cassava is a good quality carbohydrate source with ME value of 12.8 MJ per kg of feed and could be substituted for maize or barley (Balagoplan, 2004). Although the protein content of cassava is reported to be low, it has comparable energy content and lower price than maize (McDonald *et al*., 2002; Etalem, 2013). Study in Nigeria showed that sun-dried cassava peel meal and cassava tuber meal were used in layer diet to replace up to 50% of maize without any adverse effects on laying performance of chickens (Oladunjoye *et al*., 2010; Anaeto and Adighibe 2011). Similarly, Berihun *et al*. (2021) reported that complete replacement of maize

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grain with cassava tuber meal in layers ration reduced feed cost and improved economic performance without adverse effect on production parameters and health status of birds. The high cost of cereals uncertainty about their sustainable supply led to the search for alternative feed resources. Corn grain is the major source of energy for chicken feeds. But it is getting expensive due to increased demand resulting from expansion in livestock industry and ethanol production worldwide. Replacing such cereals by other source of raw materials, which are less exploited, is one of the solutions to reduce cost of production and contribute to increased supply of animal protein. Among the many products which could be used to develop feed for chicken, cassava tuber meal can be considered as a potential energy source feed ingredient.

Therefore, the present study is designed to evaluate the effect of substituting maize with different levels of peeled sun-dried cassava tuber meal on egg production, egg quality, feed consumption, feed conversion ratio, and economic performance of white leghorn chickens.

Materials and Methods

Study Area

The experiment was conducted at Haramaya University poultry farm, Ethiopia located at 42° 3' E longitude, 9° 26' N latitude and elevation of 1980 meter above sea level. The annual mean rainfall of the area is 790 mm and the average minimum and maximum temperatures are 8 and 24 °C, respectively (Wondafrash *et al.*, 2015).

Feed Ingredients and Experimental Rations

The feed ingredients used in the formulation of the different experimental rations of the study were maize grain, peeled sun-dried cassava tuber meal (PSCTM), wheat short, noug seed cake, soybean meal, vitamin premix, salt and limestone. Except for wheat short, soybean meal, vitamin premix and the rest ingredients were ground at Haramaya University feed mill before mixing. Cassava tuber was purchased from southern part of the country (Gofa-Sawella district). Whole fresh cassava tubers were cleaned, peeled and cut into small pieces, then spread on a platform under shade with good ventilation and dried for 4-5 days. The dried cassava slice was hammer milled (about 0.5cm sieve size). Samples were taken from each ingredient for chemical analysis before formulating the treatments diets (Table 1). Analysis was conducted for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash content following the proximate method of analysis (AOAC, 1995). Calcium content was determined by atomic absorption spectrophotometer and total phosphorus content by SP75 UV/vis spectrophotometer. Then after, five treatment rations containing 0%, 25%, 50%, 75%, and 100% PSCTM were formulated as a replacement of maize for T_1, T_2, T_3, T_4, and T_5, respectively (Table 1). The five treatment rations used in this study were very close in their energy and protein content (isocaloric and isonitrogenous). As planned, the ME/kg DM ranged 2900-3000 and CP ranged 16-16.3% which is within the range of nutrient requirements of layers.

Table 1. Proportion of ingredients (%) in the experimental rations.

Ingredients	Treatment diets				
	T1	T2	T3	T4	T5
Maize	41.7	31.3	20.9	10.4	0
Cassava	0	10.4	20.9	31.3	41.7
Wheat short	18	15	12	9	6
Soybean meal	8	10	12	14	17
Noug seed cake	23	24	25	26	26
Lime stone	8	8	8	8	8
Salt	0.5	0.5	0.5	0.5	0.5
Vitamin premix[1]	0.8	0.8	0.8	0.8	0.8
Total	100	100	100	100	100

[1]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), 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%).

Management of Experimental Birds

The birds were kept in a deep litter house partitioned into pens by wire-mesh, and the floor covered with litter material of *tef* straw at about 5 cm depth. Before the commencement of the experiment, the experimental pens, watering, feeding troughs and laying nests were thoroughly cleaned, disinfected, and sprayed against external parasite. One hundred and ninety-five hens and cockerels of similar age (32 weeks) with initial body weight of 940.04±32.2 g (mean ± S.D.) were randomly distributed to five treatments. The birds were divided into three replicates with thirteen layer hens and two cockerels per replicate in complete randomized design (CRD) experiment. The birds were adapted to experimental diets for 7 days before the actual data collection. Feed was offered to the birds *ad libitum*.

Data Collection and Measurements

The amount of feed offered and refused per pen was recorded daily. The amount of feed consumed was determined as the difference between the amount of feed offered and leftover on DM basis. Body weights were recorded individually at the beginning of the experiment (initial body weight) and the end of the study period (final body weight) and body weight change was calculated as the difference between final and initial body weight. Eggs were collected three times a day at 0800, 1300, and 1700 and the sum of the three collections was considered as the daily egg production. Egg weight was determined for each pen on daily basis by dividing the total egg weight to the total number of eggs. The egg mass per hen was calculated by multiplying egg production per hen by the average EW. Egg production performance of each replicate was expressed as the average percentage hen-day egg production following the method of Hunton (1995) as follow:

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

$$\%\ \text{Hen} - \text{housed egg production} = \frac{\text{Number of eggs counts in experimental periods}}{\text{Original number of hens x experimental days}} \times 100$$

Feed conversion ratio was determined as gram of feed consumed per gram of egg produced. Egg quality parameters measured and determined in this study were egg weight, shell weight, shell thickness, yolk height, yolk weight, yolk color, yolk index, yolk diameter, albumen height, albumen weight and Haugh Unit Score. A total of 480 eggs were used for quality analysis. Egg weight, shell weight, albumen weight and yolk weight were measured using sensitive balance. Eggshell thickness was measured after removing the shell membrane from three sides of the egg; one at the large end (top or pointed part), at the narrow end and from the middle part of the egg by using micrometer gauge. The average of the three sites was taken as eggshell thickness. Yolk color was measured with Roche fan having 15 color scales ranging from pale to orange-yellow. The Haugh unit was computed using the following formula (Haugh, 1937).

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

Where, HU=Haugh unit(g); G=gravitational constant, i.e. 32.2; H=albumin height(mm); W=weight of egg(g).

Yolk index was also computed using the following formula:

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk diameter}} * 100$$

Data Analysis

All the data collected in this study were subjected to statistical analysis using SAS computer software version 9.1 (SAS, 2008). Least significant difference (LSD) method was used to locate the treatment means that were significantly different (SAS, 2008). The procedure for egg yolk color is logistic regression.

Results

Chemical Composition of Ingredients and Rations

The results of chemical analysis and calculated ME values of ingredients shows comparable energy value and crude fiber content for maize grain and cassava meal (Table 2). The fiber content of maize and cassava are also similar. However, the protein content of cassava was less than maize grain.

The crude protein and metabolizable energy contents of treatment rations were comparable throughout inclusion levels ranged 16-16.3% and 3041.5-3106.1 kcal/kg DM (Table 3), respectively. The calcium contents of the treatment diets increased as the inclusion of peeled sun-dried cassava tuber meal increased. Nutrient content of treatment rations is within the recommended ranges for layers.

Production Performances

Substitution of PSCTM for maize grain in the ration had no effect (P>0.05) on daily dry matter intake of laying hens (Table 4). Bodyweight change of birds assigned to T2 was significantly (P<0.05) higher than those in T1, T3, T4 and T5. Higher hen day egg production and egg mass and better feed conversion ratio was exhibited by hens in T3 than those in T2, T4 and T5. However, the results in the control group (T1) were similar (P>0.05) with that of T3. The hen housed egg production in T3 was higher (P value here) than all the rest. There were no significant (P>0.05) effects of treatment on egg weight.

Table 2. Chemical composition and calculated energy value of feed ingredients used to formulate experimental rations.

Chemical composition	Feed ingredients				
	Maize	Cassava	Wheat short	Soybean meal	Noug seedcake
DM%	90.0	89.2	90.3	93.0	92.1
CP (%DM)	8.5	2.2	14.7	39.0	29.6
EE (%DM)	6.2	0.8	3.3	9.2	8.1
Ash (%DM)	5.9	2.6	5.5	5.8	9.1
CF (%DM)	2.8	2.1	9.9	5.7	18.3
NFE (%DM)	76.6	92.2	66.5	40.3	34.8
Ca (%DM)	0.02	0.25	0.19	0.35	0.35
P (%DM)	0.92	0.44	0.78	0.83	0.32
ME (kcal/kg)	3798.7	3699.6	3030.7	3710.9	2401.9

DM= Dry matter; CP= Crude protein; EE= Ether extract; NFE= Nitrogen free extract; CF= Crude fiber; Ca= Calcium; P= Phosphorus; ME= Metabolizable energy.

Table 3. Chemical composition of treatment diets containing different proportions of peeled sun-dried cassava tuber meal as a substitute for maize.

Chemical composition	Treatments				
	T1	T2	T3	T4	T5
DM (%)	90.7	90.8	90.4	90.5	90.9
CP (% DM)	16.3	16	16	16.3	16.2
Ash (% DM)	13.3	12.3	11.5	11.8	13.5
EE (% DM)	6.7	6.2	5.4	6.2	5.1
CF (% DM)	8.1	8.4	7.6	7.9	6.8
P (% DM)	0.42	0.45	0.32	0.31	0.3
Ca (% DM)	3.2	3.1	3.4	3.7	3.7
ME (kcal/kg)	3041.5	3054.4	3101.4	3106.1	3074.5

DM= Dry matter; CP= Crude protein; EE= Ether extract; CF= Crude fiber; P= Phosphorous; Ca= Calcium; ME= Metabolizable energy; PSCTM= Peeled sun-dried cassava tuber meal; T1, T2, T3, T4, and T5= Rations containing 0%, 25%, 50%, 75%, and 100% PSCTM as a substitute for maize grain, respectively.

Table 4. Dry matter intake, body weight gain and egg production performance of white leghorn hens fed ration containing different levels of peeled sun-dried cassava tuber meal.

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
DMI (g/bird/day)	80.7	87.5	80.8	83.4	83.0	1.02	NS
Initial BW (g/bird)	938.0	927.2	947.7	947.9	939.4	8.3	NS
Final BW (g/bird)	1157.7^{b}	1254.6^{a}	1121.4^{b}	1180.1^{b}	1143.9^{b}	15.05	*
BW gain (g/bird)	219.8^{b}	327.4^{a}	173.7^{b}	233^{b}	204.5^{b}	17.0	*
AD gain (g/bird)	0.2^{b}	0.27^{a}	0.2^{b}	0.21^{b}	0.2^{b}	0.03	*
Total egg/hen	50.0^{b}	46.0^{b}	56.0^{a}	47.0^{b}	48.0^{b}	1.2	*
HDEP (%)	57.5^{ab}	52.3^{b}	64.1^{a}	54.0^{b}	54.0^{b}	1.4	*
HHEP (%)	55.5^{b}	51.3^{b}	62.5^{a}	52.7^{b}	53.5^{b}	1.3	*
Egg weight (g)	50.4	49.8	50.4	50.2	50.1	0.09	NS
EM (g/hen/day)	28.9^{ab}	26.1^{b}	32.3^{a}	27.1^{b}	26.9^{b}	0.08	*
FCR (g feed/g egg)	3.2^{ab}	3.8^{c}	2.9^{a}	3.5^{bc}	3.5^{bc}	0.11	*

$^{a-c}$Means within a row with different superscripts differ significantly (P < 0.05); SL= Significant level; NS= Non-significant; DMI= Dry matter intake; BW= Body weight; FCR= Feed conversion ratio; HDEP= Hen–day egg production; HHEP= Hen-housed egg production; EM= Egg mass; SEM= Standard error of mean; PSCTM= Peeled sun-dried cassava tuber meal; T1, T2, T3, T4, and T5= Rations containing 0%, 25%, 50%, 75%, and 100% PSCTM as a substitute for maize grain, respectively.

Egg Quality Parameters

Substituting maize grain with peeled cassava tuber meal has no effect (P>0.05) on all egg quality parameters except yolk color (Table 5). Egg yolk color in hens supplemented with PSCTM (T5, T4, T3, and T2) was significantly higher (P<0.05) than eggs from the control treatment.

Table 5. Egg quality parameters of white leghorn hens fed ration containing different levels of peeled sun-dried cassava tuber meal.

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Sample Egg weight (g)	51.1	48.7	51.6	51.4	51.2	0.39	NS
Shell weight (g)	5.6	5.25	5.9	5.8	5.7	0.08	NS
Shell thickness (mm)	0.3	0.31	0.32	0.3	0.31	0.01	NS
Albumen height (mm)	8.2	8.6	8.7	0.8.6	8.6	0.12	NS
Albumen weight (g)	28.9	28.1	29.7	29.2	29.2	0.22	NS
Yolk height (mm)	15.6	15.3	15.5	15.5	15.4	0.07	NS
Yolk weight (g)	14.9	14.0	14.6	14.8	14.7	0.13	NS
Yolk color score	2.0^{c}	2.6^{b}	2.6^{b}	2.8^{ab}	3.2^{a}	0.14	*
Yolk diameter (cm)	3.6	3.5	3.6	3.6	3.6	0.01	NS
Yolk index (mm)	0.44	0.43	0.48	0.47	0.47	0.14	NS
Haugh unit	91.9	95.2	95.3	94.3	94.7	0.22	NS

$^{a-c}$Means that row values with different superscripts differ significantly (P < 0.05); SEM= Standard error of mean; SL= Significant level; NS= Non-significant; PSCTM= Peeled sun-dried cassava tuber meal; T1, T2, T3, T4, and T5= Rations containing 0%, 25%, 50%, 75%, and 100% PSCTM as a substitute for maize grain, respectively.

Table 6. Yolk color points of egg samples from experimental diets.

Diets	Roche yolk color points									
	1	2	3	4	5	6	7	8	9	Total
T1	28	48	18	2	0	0	0	0	0	96
T2	23	29	23	14	5	1	0	0	1	96
T3	16	37	27	11	3	0	0	1	1	96
T4	8	24	28	26	6	3	0	0	1	96
T5	0	23	45	16	8	2	2	0	0	96
Total	53	161	155	72	25	6	3	2	3	480

T1= Ration containing 0% PSCTM; T2= Ration containing 25% PSCTM as a substitute for maize grain; T3= Ration containing 50% PSCTM as a substitute for maize grain; T4= Ration containing 75% PSCTM as a substitute for maize grain; T5= Ration containing 100% PSCTM as a substitute for maize grain.

Partial Budget Analysis

The economics of egg production determined from ratios of cost of the total feed consumed and the egg mass produced from that amount of feed indicated that the ration containing 50% PSCTM is the least cost ration followed by 0% PSCTM, 75% PSCTM and the ration containing 100% PSCTM (Table 7).

Table 7. Economics of feeding peeled sundried cassava tuber meal.

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Total feed intake (kg/bird)	7.7	8.5	7.9	8.1	8.2	0.11	NS
Total feed cost (birr)	48.6	52.9	48.4	48.9	50.1	0.40	NS
Feed cost per kg of egg mass	20.2[b]	23.6[a]	17.7[c]	21.0[b]	21.3[b]	0.07	*

[a-c]Means within a row with different superscripts differ significantly ($P < 0.05$); Birr= Ethiopia's unit of currency; US$1.00= Birr 29.21 (2019 G.C); T_1= Diet containing 0% PSDCTM of maize grain; T_2= Diet containing 25% PSCTM of maize grain; T_3= Diet containing 50% PSCTM of maize grain; T_4= Diet containing 75% PSCTM of maize grain; T_5= Diet containing 100% PSCTM of maize grain; SEM= Standard error of mean; SL= Significant level; NS= Non-significant.

Discussion

Chemical Composition of Ingredients and Ration

From the analysis result, it was seen that maize and cassava are rich in energy content with almost similar energy value (3798.7 and 3699.6, respectively) that make cassava to be an energy feed and good potential substitute for maize in poultry ration.

The energy content of cassava tuber reported by Aina and Fanimo (1997) and Anyanwu *et al.* (2008) is 3200 kcal/kg and 2680 kcal/kg, respectively which is lower than value obtained for cassava in the current experiment. However, the CP, EE and total ash contents of PSCTM are almost similar with that reported by Heuzé *et al.* (2012), which are 2.2, 0.8 and 2.8%, respectively. Anaeto and Adighibe (2011) noted that chemical composition of cassava varies according to environment, variety, plant age and processing technology employed. The CP and ME levels were within the ranges of the recommended levels of 16-18% and 2500-3300 kcal/kg, respectively for white leghorn layers (Leeson and Summers, 2001). Calcium contents of the treatment diets increased as the inclusion of peeled sun-dried cassava tuber meal increased. This may be due to greater calcium contents of cassava tuber than maize grain (Table 1).

Production Performances

Similar feed intake among the treatments in the current study is in agreement with Aina and Fanimo (1997) who found no significant effect in feed intake up to 100% replacement of maize with cassava tuber meal. However, Anaeto and Adighibe (2011) reported reduced feed intake as the level of cassava tuber meal in the diet increased. They attributed the decline feed intake to the dustiness of the meal, which could be attributed to the method of meal preparation, and the high hydrocyanic acid content of cassava variety used that created palatability problems.

Better HHEP, HDEP, and EM egg production recorded for T3 than T5, T4, and T2 may be due to the improvement in nutrient balance when cassava and maize are included in the diet in equal proportion. The result is in line with Khdarern and Kbjarem (1991) where better chicken performance is supported by partial substitution (50%) of cassava for cereal than the control diets or total substitution with cassava. The rate of lay at 50% replacement level observed in this experiment disagreed with the findings of Senkoylu *et al.* (2005) and Aderemi *et al.* (2006) who noted cassava tuber meal inclusion above 50% reduced egg production as compared to the control. Higher egg number, HDEP, HHEP, and EM in T3 compared with T5 and T4 disagree with Akinola and Oruwari (2007) who noted increased egg production as the level of cassava tuber meal increases up to 100%. The significant improvement in egg production was obtained when the two energy diets were combined at a ratio of 50:50 percent.

Egg Quality Parameters

The color of the yolk is determined by the presence and absence of xanthophylls, some of which are precursors of vitamin A (Smith, 1996). Geneva *et al.* (2014) reported that cassava tubers contain vitamin A. Similarly, FAO (2003) noted that cassava has high carotene content. Therefore, the color of the yolk is influenced to a large degree by nutrition of the birds. The present result showed that as the level of PSCTM increased, the intensity of yolk color increased. The present finding disagrees with Anaeto and Adighibe (2011) who reported that replacing 50% of the maize in the ration by cassava tuber meal resulted in the reduction of the intensity of the yellow yolk pigmentation, because of the low carotene content of cassava.

Partial Budget Analysis

Based on the result of current study, the substitute of maize grain with PSCTM up to 75% is more economical. Complete (100) the substitute of maize grain with PSCTM improve yolk color and there was no negative impacted on egg quality parameter, feed intake, egg weight, and adverse effect was not observed on egg production as compared with control diet. Therefore, based on the current research result, cassava can substitute maize grain up to 100%.

Conclusion

As the price of maize increased from day to days due to the competition for human consumption, replacing it with cassava tuber meal by 50% appeared to improve the weight and egg production performance of layers.

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Conflict of Interests

The authors declare that they have no competing interests.

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