# Substituting maize with blends of Solanum tuberosum chips and Ensete ventricosum corm on egg production and quality in Bovans Brown

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## Abstract

The experiment was conducted in the Sodo district of the Gurage zone, in the central highlands of Ethiopia, to ascertain the effects of substituting enset (*Ensete ventricosum*) corm and potato (*Solanum tuberosum*) chips for corn on the quantity and quality of eggs laid by Bovans brown layers. A total of 132 Bovans brown layers aged 24 weeks were used in the investigation. All 132 of the Bovans brown layers in the study were 24 weeks old. In place of maize grain, the layers were fed feed that contained 0% (T1), 15% (T2), 30% (T3), and 45% (T4) of a potato chip and enset corm mixture. The trial was totally randomized and comprised four treatments. With 11 birds apiece, each treatment was carried out three times. A 12-week experiment was conducted. Hens were weighed at the start and end of the trial. Dry matter intake, hen-day egg production (HDEP), egg weight, and egg mass were all tracked daily. Every 15 days, four eggs per replicate were evaluated for four different egg quality metrics (egg shell weight and thickness, albumen weight and height, Haugh unit and yolk weight, and color). Mix of potato chips and enset corms with 3568 kcal/kg DM, 4.28% CP, 0.17% ether extract, and 2.40% crude fiber. The average daily increases of T1 (2.08g), T4 (1.99g), and T3 (1.85g) were comparable and significantly larger (P 0.05) than T3 (1.28g). The egg mass and feed conversion ratios among treatments were statistically comparable ($P < 0.05$). T1's (81.08%) HDEP was equivalent to and significantly (P 0.05) higher than T3 (84.07%), T4 (83.61%), and T2 (83.34%). Compared to T1 and T3, T4 showed a higher eggshell weight (P 0.05). As a result, enset corm and potato chips can be combined to substitute maize in layer rations when it is scarce in enset and potato-growing regions.

## Introduction

Most impoverished countries in the tropics rely heavily on scavenging methods for poultry production. Because of the use of this management style, there has been a high death rate and low productivity. While village chicken production systems in tropical locations face major challenges, they play a vital role in rural communities' livelihoods. Due to a variety of technological issues, the productivity of poultry farming in developing nations per unit of bird and the contribution of this sector to the national economy of the country are relatively low. Feed shortages and the high cost of conventional energy and protein sources are the primary problems limiting poultry output in Ethiopia (Atawodi 2008; Aberra et al. 2011). Feed materials utilized in commercial poultry production are high-quality grains that are also consumed by humans. This puts the sector in direct competition for grains, raising the cost of poultry production (Gura 2008; Mengesha 2011).

Ethiopia has unique agro-climatic conditions that promote the cultivation of many different types of food and feed crops, resulting in a diversified range of alternative feeds ideal for poultry feeding (Tadelle et al. 2002). *Ensete ventricosum* is one such crop that can potentially be supplemented in poultry feed. The most significant components of the enset are the pseudo-stem, corm, and stalk of the inflorescence (Adugna 2008). More than 70% of the enset plant's parts are pseudo-stem and corm (Ajebu et al. 2008). The corm, or underground stem, of enset is employed for vegetative propagation of the plant. It is a sustainable food supply that may be uprooted and consumed at any moment during the plant's life cycle, especially during a prolonged drought. Enset corm contains a lot of highly soluble carbohydrates and starch but not much fiber or cellulose (Mohammed et al. 2013). According to Mohammed et al. (2013), enset corm contained 17 of the 20 amino acids in concentrations ranging from 1.2 to 8.7 g per 100 g of protein and from 25.6 to 186.6 mg per 100 g of corm, with the quantities of most amino acids being higher than those of potatoes. The high biomass output and year-round availability of enset green may make it one of the finest alternatives for chicken feeding (Ajebu et al. 2008).

Potato (*Solanum tuberosum*) has a great production capacity (fresh tuber yield, 20 tons/ha), whereas maize and wheat yield 5 tons/ha and 7 tons/ha, respectively, and can adapt too many soil types. It is an energy source that could replace maize or other cereals used for layer feeding. The energy value of potato meal (PM) used is more than 2830 ME per kg. On a dry matter basis, potato meal (PM) comprises more than 65% starch, 6.74% ash, 12.72% CP, 23.48% CF, and 0.99% EE. Potato meal is said to be less expensive than maize and wheat (PAN, 1995). As a result, looking for locally available non-traditional feed resources such as enset and potato to design poultry rations may be necessary.

Regardless of the method of production, the cost, availability, and quality of feed ingredients significantly restrict the capacity to produce animals for the general public through chicken farming. Feed cost is sometimes blamed for the high price of chicken products; it is believed to account for more than half of the entire cost of intensive chicken production (Wilson and Beyer 2000). Maize grain has been employed as an energy source in poultry diets, raising the cost of poultry feed. The increasing demand for energy and protein for human consumption has sparked research interest, particularly in developing countries, in the quest for locally accessible alternative feed ingredients for chicken feeding that are relatively cheaper. To enhance chicken productivity, poultry producers must look beyond cereal grains (Chauynarong et al. 2009; Swain et al. 2014).The current study was designed to find out the effects of replacing maize with a combination of enset corm and potato chips on feed intake, body weight changes, and feed conversion ratio in Bovans brown layers, as well as the effects of doing so on egg production and egg quality traits in Bovans brown layers.

## Materials and Methods

# About the study area

The experiment was carried out in the Sodo district of Gurage Zone, in the central Ethiopian highlands. It can be found at 8°18'5' N and 38°32'48' E, around 105 kilometers south of Addis Ababa. The research area's mean annual temperatures and rainfall are 17°C and 1021.7 mm, respectively. The elevation range is 1700–3460 meters above sea level. The farming activity includes the production of crops and the care of livestock. In the study area's highlands, enset and potatoes are the principal crops grown for domestic use (SWSNRMO 2018).

# Experimental feed preparation and treatments

Farmers in Sodo district, Sewati Kebele, central Ethiopia, sold us enset plants of the "Ashakti" kind that were 5–6 years old. After cutting off the aerial portion of the enset plant, a fresh enset corm was scooped out. Whole fresh enset corms were washed, cleaned, and sifted before being peeled, cut into little slices, and sun-dried for five days over a plastic sheet. In order to avoid uneven drying and degradation, it was constantly turned. Potatoes were purchased from a neighborhood market. Skins were removed after thorough filth and dust cleaning. A potato chunk was then exposed to sunlight to dry. The right precautions were taken to avoid the growth of fungus when drying the potatoes. Following mechanical grinding of the sun-dried potato and the acquisition of feed components from a nearby market, the following substances were used to create the study's rations: maize grain, enset corn, potato, wheat middling, noug seed cake, soybean meal, vitamin premix, salt, lime stone, and dicalcium phosphate. The following items were ground to pass through a 5 mm sieve: dried enset corm, dried potato, maize grain, nougat seed cake, salt, and limestone.

The chemical compositions of the major feed constituents were identified from representative samples. The four treatment rations used in the current experiment were developed to be nearly iso-caloric and iso-nitrogenous, with 2800 kcal ME/kg DM and 16.0% CP, in order to meet the nutrient needs of layers (Leeson and Summers 2008). In Ration 1 (control), neither test feed, potato chips, nor enset corm were employed. In rations 2, 3, and 4 for treatments 1, 2, 3, and 4, enset corm and potato chips were mixed in proportions of 15% (10% enset corm and 5% potato chips), 30% (20% enset corm and 10% potato chips), and 45% (30% enset corm and 15% potato chips), respectively (Table 1).

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

| **Ingredients** | **Treatments, means** | | | |
|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** |
| Maize | 43.5 | 37 | 30.5 | 19.5 |
| ECPCM | - | 6.5 | 13 | 24 |
| Wheat middling | 18.5 | 17.5 | 16.5 | 15.5 |
| Noug cake | 15 | 16 | 16 | 16.5 |
| Soybean meal | 14 | 14 | 15 | 15.5 |
| Vitamin premix* | 1 | 1 | 1 | 1 |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 |
| Lime stone | 7 | 7 | 7 | 7 |
| Dicalcium phosphate | 0.5 | 0.5 | 0.5 | 0.5 |
| Total | 100 | 100 | 100 | 100 |

T1, 0% MECPC; T2, 15% MECPC; T3, 30% MECPC; T4, 45% MECPC as substitute to maize

Soy meal, nougat seed cake, wheat middling, limestone, vitamin premix, dicalcium phosphate, and salt were all ingredients in the treatment meals. Water is accessible at all times in individual troughs for each pen. Nigussu et al. (2016) claim that it is favorable for enset-growing regions since it is always available to utilize enset corm up to 30% of the time in place of maize in the composition of chicken meals. Afolayan et al. (2013) found that when maize was substituted for sweat potato meal in laying hen diets by 20%, there were no discernible variations in the feed costs per kilogram of egg production or laying performance. The feeding benefit of a combination of enset corm and potato chips for broilers and layers has not been investigated.

# Management of Experimental Birds

With the aid of wire mesh and 10 cm of sawdust, 12 pens, each measuring 2 x 1.4 metres, were created inside the experimental home. The experimental pens, watering apparatus, feeding troughs, and laying nests were properly cleaned, disinfected, and treated against external parasites before the actual experiment got underway. The chickens received vaccinations against common poultry diseases as fowl pox and Lasota. Along with water; multivitamin tablets and oxytetracycline (20 g/100 l of water) were administered. All through the experiment, free access to clean water was provided. For the experiment, 132 Bovan Broun chicken layers were employed, each weighing 1.67 0.033 kg (Mean SD) and having a lifespan of 24 weeks. Golden Poultry Production and Multiplication Centre provided the meat for the study in the form of pulled chicken. The birds were housed for seven days to allow for adaption. Four treatments were given a total of 33 layers each in a completely randomized design (CRD); each treatment was repeated three times and included 11 layers.

# Laboratory analysis

In order to pass past a 1 mm screen for chemical analysis, dried feed samples were milled. Following the proximate technique of analysis, samples were examined for dry matter, crude protein, ether extract, crude fiber, and ash (AOAC 2000). This analysis was performed in the animal nutrition lab at Jimma University. In the chemistry lab at Arba Minch University, the contents of calcium and total phosphorus were measured using the atomic absorption and vanado-molybdate methods, respectively (AOAC 2000). By subtracting 100 from (CP + CF + EE + ash), the nitrogen free extract (NFE) was calculated. By using the Kjeldal technique to quantify nitrogen, crude protein (CP) will be computed by multiplying N by 6.25. The experimental diets' metabolisable energy (ME) content was determined using an indirect method based on the following Wiseman (1987) equation: ME (Kcal/kg DM) = 3951 + 54.4EE − 88.7CF − 40.8 ash.

# Feed intake

Every day, at the same times of 0600 and 1500, a weighted amount of feed was provided, and fresh tap water was always available. The food was provided in hanging circular plastic feeders that were around the height of the birds' backs. A circular plastic drinker containing water was also available. In accordance with the recommendations of the manufacturer, vitamins were administered through drinking water. There was a separate nest in each pen, which was coated with sawdust. After removing external impurities by ocular inspection, orts were collected and weighed. The feed offer and refuse for each replication were noted and multiplied by the appropriate DM content. The difference between the feed offered and rejected on a per-DM basis was used to calculate the amount of feed consumed. For three months, samples of feed that were provided and rejected daily based on treatments were bulked up for chemical analysis.

# Body weight change and feed conversion ratio

Body weights (BW) were recorded both at the beginning and conclusion of the trial. The difference between the final and starting body weights was used to calculate the body weight change. The weight of feed consumed per egg mass was calculated to obtain the feed conversion ratio for each replicate. According to Melkamu (2017), the average feed conversion ratio for each treatment was calculated as the average of the replicates for each treatment.

# Egg production

Three times a day, at 7:00 a.m., 12:00 a.m., and 6:00 p.m., eggs were removed from each pen. At the conclusion of the time period, the three collections' combined total as well as the number of birds' active each day were noted and compiled. Using the average results from each duplicate and applying Hunton's technique (1995), the rate of lay for each treatment was calculated as the average percentage of hen-day egg production as follows:

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

# Egg weight and egg mass

By dividing the total egg mass by the number of eggs, the average egg weight (AEW) was computed. For each treatment, daily collected eggs were weighted by sensitive balance immediately after collection.

# Egg quality parameters

Egg quality indicators such egg size, width, weight, and thickness as well as albumen, yolk, and albumen height and weight At intervals of two weeks, the size, color, and height of four freshly deposited eggs per replicate were measured. A total of 192 eggs—48 for each treatment—were used for the quality examination. A 0.0-gram-sensitive digital scale was used to measure the weight of the eggs. The egg's length and width were measured using a digital caliper. The following equation is used to estimate the Shape Index (SI): Shape Index = [egg width/egg length] × 100 (Anderson et al. 2004). The internal measurements were collected after the egg sizes were measured externally by carefully poking a hole through the egg's pointed end large enough to allow the albumen and yolk to pass through without mingling their contents. Next, the albumen is carefully separated from the yolk, which is then put in a petri dish for weighing. The corresponding albumen is simultaneously placed on a different petri dish and weighed. The weight difference between the petri plates used to weigh the egg contents after and before the egg component is used to calculate the weight of the egg components.

Before the subsequent weigh-in, the petri dishes were cleaned in clean water after each weigh-in and dried. Digital calipers were used to measure the height of the albumin and yolk. By carefully inserting the opened section into the shell and weighing it on a digital balance, the weight of the shell and membrane was determined. Three different locations (the large end, the small end, and the equator region of the eggshell) were used to measure the thickness (mm) of the shell with intact membranes, and the average value was acquired using a digital vernier caliper. The following equation was used to determine the yolk index (Elnagar and Abd-Elhady 2009):

Yolk diameter (cm) = [Yolk height (cm)/Yolk index (%)].

The color of a correctly mixed yolk sample placed on white paper was compared to 1–15 Roche fan measuring color strips, which vary from pale to orange yellow in color, to determine the yolk's color. Using the Haugh (1937) formula, the Haugh unit was determined from the egg weight and albumen height.

Albumen quality is quantified by the Haugh unit (HU) (Keener et al. 2006). The shattered eggs' albumen and yolk were meticulously sorted. The height of the albumen and yolk was measured using a tripod micrometer. The weight of Al. bumen was determined using a digital balance. The following formula was used to determine the HU (Raji et al. 2009).

$$HU = 100\ (H + 7.5\ 1.7W0.37)$$

Where, HU stands for the Haugh unit, H for albumen height, and W for egg weight (in grams).

# Statistical analysis

The statistical analysis software system (SAS Institute, Inc., 2008 version 9.2) used the general linear model (GLM) method to do an analysis of variance (ANOVA) on the obtained data. The least significant difference (LSD) was used to differentiate the meaningful difference between the treatment means. At $P < 0.05$, the treatment effect was deemed significant. The experiment made use of the following model:

$Y_{ij} = \mu + \alpha_i + \ _{ij}$,

Where,

$Y_{ij}$ = represents the $j^{th}$ observation in the $i^{th}$ treatment level, $\mu$ = over all mean, $\alpha_i$ = treatment effect, $\ _{ij}$ = random error.

## Results

# Chemical makeup of ingredients in feed and experimental rations

The chemical composition and metabolizable energy value of feed ingredients and treatment meals, respectively, are shown in Tables 2 and 3. When compared to other feed items, the mixture of enset corm and potato chips had the lowest CP (4.28%), EE (0.17%), and NFE value (88.73). The soybean had the highest CP value, followed by the nougat seed cake. Maize had the highest metabolizable energy value, followed by a blend of enset corm and potato chips and Wheat middling, while nougat cake had the lowest value. The CP content of the treatment diets was comparable. The metabolic energy values of the treatment diets were comparable, while T4 was somewhat lower.

Table 2
The chemical composition of feed stuffs (on Dry matter basis)

| **Ingredients** | **Chemical composition of feed stuffs (%)** | | | | |
|---|---|---|---|---|---|
| | **MECPC** | **Maize** | **NSc** | **Wheat middling** | **SBM** |
| DM (%) | 92.19 | 90.29 | 93.62 | 90.93 | 96.32 |
| CP(%DM) | 4.28 | 8.16 | 28.76 | 12.64 | 45.50 |
| EE(%DM) | 0.17 | 3.80 | 11.91 | 1.96 | 4.95 |
| Ash(%DM) | 4.42 | 3.18 | 10.18 | 3.62 | 5.92 |
| CF(%DM) | 2.40 | 3.70 | 20.12 | 7.80 | 12.30 |
| Ca(%DM) | 0.04 | 0.04 | 0.04 | 0.20 | 0.02 |
| P(%DM) | 0.38 | 0.72 | 0.71 | 0.51 | 0.36 |
| ME(kcal/kg DM) | 3568 | 3695 | 1930 | 2924 | 2887 |
| NFE | 88.73 | 81.19 | 29.03 | 73.98 | 31.33 |

DM, dry matter; CP, crude protein; EE, ether extract; CF, crude fiber; Ca, calcium; P, phosphorus; ME, metabolizable energy; NFE, Nitrogen free extract; MECPC, mixture of enset corm and potato chips; NSC, Noug seed cake.

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

| | Treatments, Means | | | |
|---|---|---|---|---|
| **Nutrients** | **T1** | **T2** | **T3** | **T4** |
| Dry matter (%) | 92.52 | 92.67 | 92.84 | 93.01 |
| Crude protein | 16.57 | 16.48 | 16.56 | 16.55 |
| Crude fiber | 7.79 | 7.83 | 7.79 | 7.79 |
| Ether extract | 4.50 | 4.36 | 4.15 | 3.98 |
| Ash | 16.25 | 16.42 | 16.44 | 16.54 |
| Calcium | 3.22 | 3.22 | 3.22 | 3.22 |
| Phosphorus | 0.65 | 0.63 | 0.61 | 0.59 |
| Nitrogen free extract | 54.89 | 54.88 | 55 | 55.14 |
| ME (kcal/kg DM) | 2841.95 | 2823.75 | 2815.13 | 2801.71 |

T1 = 0% MECPC; T2 = 15% MECPC; T3 = 30% MECPC; T4 = 45% MECPC as substitute to maize.

# Feed intake and egg laying performance

The DM consumption of hens fed T2 meals was lower than that of other treatments, although the DM intake of hens fed T1, T3, and T4 diets did not differ ($P > 0.05$) (Table 4). Body weight gain in hens fed T3 meals was lower ($P > 0.05$) than in other treatments, although body weight gain in hens fed T1, T2, and T4 diets was equivalent ($P > 0.05$) (Table 4).T2, T3, and T4 diets produced more hen-day eggs ($P > 0.05$) than T1 diets. Egg mass and weight were comparable ($P > 0.05$) among treatments. Layers given T1 (the control diet) had a higher feed conversion ratio than T2, T3, and T4 layers fed equal values.

Table 4
Dry matter intake, body weight change and egg laying performance of Bovans brown hens fed mixture of enset corm and potato chips as substitute to maize.

| | Treatment, Mean | | | | | |
|---|---|---|---|---|---|---|
| Variables | T1 | T2 | T3 | T4 | SEM | P-value |
| DM intake (g/hen/d) | 119.62$^{a}$ | 118.38$^{b}$ | 118.86$^{b}$ | 116.03$^{c}$ | 0.142 | 0.040 |
| Initial body weight(kg) | 1.67 | 1.68 | 1.65 | 1.67 | 0.001 | 0.891 |
| Final body weight(kg) | 1.86$^{a}$ | 1.85$^{ab}$ | 1.77$^{b}$ | 1.85$^{ab}$ | 0.002 | 0.100 |
| Body weight gain (g/hen/day) | 2.08 | 1.85 | 1.28 | 1.99 | 0.273 | 0.302 |
| Egg weight(g) | 58.05 | 58.35 | 58.47 | 58.32 | 0.834 | 0.950 |
| Hen day egg production (%) | 81.08 | 83.34 | 84.07 | 83.61 | 2.553 | 0.180 |
| Egg mass (g/hen/day) | 49.61 | 49.04 | 49.53 | 49.52 | 0.221 | 0.120 |
| FCR (g feed DM/g egg) | 2.47$^{a}$ | 2.42$^{a}$ | 2.40$^{b}$ | 2.40$^{b}$ | 0.001 | 0.026 |

$^{a,b}$ Means within a row with different superscripts differ ($p < 0.05$);T1, 0% ECPCM; T2, 15% ECPCM; T3, 30% ECPCM; T4, 45% ECPCM as a substitute to maize; SEM, Standard Error of the Mean; FCE, Feed conversion efficiency

# Egg quality parameters

Except for the egg shell weight of eggs from layers fed a mixture of enset corm and potato chips, egg quality parameters were similar ($P > 0.05$) for layers fed rations containing 0%, 15%, 30%, and 45% enset corm and potato chips mixture diets. Egg shell weight was in the order T4 > T2 > T3 > T1 ($P < 0.05$).

## Discussion

# Chemical Composition of Feedstuffs

In the current study, MECPC was created by combining two-thirds Enset corm and one-third Potato chips. The estimated value indicated that MECPC had lower metabolizable energy (ME) than maize but greater than wheat middling, soybean meal, and nougat seed cake (NSC). MECPC, on the other hand, has lower crude fiber and crude protein levels than the other feed constituents. The CP content of the enset corm and potato chips mixture (4.28%) in the current study was greater than the CP values of enset corm (2.2%) published by Ajebu and Eik (2014) and kocho (3.8%), reported by Nigussu et al. (2019). Melese (2013) reported a higher CP (4.76%) content of kocho than the current trial. The discrepancy in CP content could be attributed to differences in the enset types used to manufacture kocho. Ajebu et al. (2008) discovered a variation in the CP content of unprocessed corm and pseudostem from which kocho is formed. In general, the CP content of enset corm is low, indicating the necessity for supplementation with CP-rich feed sources such as nougat cake and soyabean meal. On the other hand, the ME content of the enset corm and potato chips combo was higher than that of the other feed items employed in this experiment, with the exception of maize grain, which has a comparable value.

The ME content of the enset corm and potato chips obtained in this study was higher than that found by Mohammed et al. (2013), who discovered that unprocessed corm and pseudostem have 3437 and 3379 kcal/kg DM, respectively. However, it was equal to the 3647 kcal/kg DM reported for kocho by Nigussu et al. (2019). Its potential to replace the energy value of cereals like maize in layer diets is justified by the ME value of the enset corm and potato chip mixture determined in this study. The treatment meals' calcium and phosphorus concentrations were determined to be within the suggested ranges for layering. The combined enset corm and potato chip CF content (2.4%) was comparable to the values (2.3%) reported by Nigussu et al. (2019) for kocho and low compared to the unprocessed corm (5.65%) and pseudostem (7.51%) reported by Mohammed et al. (2013) for different enset varieties, but within the range of 1.47–4.42% reported by Melese (2013) for different enset varieties.

The relatively low amount of CF in the mixture of enset corm and potato chips and the high level of ME indicate that it has the potential to be used as a dairy ingredient in layer rations. According to NRC (1994), the energy and protein requirements of laying hens range from 2700 to 2850 kcal/kg dry matter and from 14.0 to 19.0%, respectively. The CP concentrations of the treatment meals ranged from 16.48 to 16.57%, which was greater than the NRC's (1994) recommended minimum CP requirement of 14%. Also, the ME content of the treatment meals ranged from 2802 to 2842 kcal/kg DM, which was higher than the NRC's (1994) minimum ME requirement of 2700 kcal/kg DM for white leghorn layer.

# Feed intake and laying performance

There is no published data on feed intake, egg production, or egg quality in layers fed a ration including a combination of enset corm and potato chips. In the current study, a 45% blend of enset corm and potato chips in the ration had the same DM intake as Bovans brown layers. Ajebu et al. (2015) reported similar dry matter intake for Hubbard grill chickens fed 0%, 33%, 67%, and 100% kocho diets, as did 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 for maize. Sultana et al. (2016) revealed that included potato meal in the layers diet resulted in slightly higher egg production and a better feed conversion ratio in the control group, which could be attributed to the hens' increased feed consumption compared to the potato meal-fed hens. Again, this lower egg production could be attributed to the high fiber content of potato meal, which results from birds' poor nutrient utilization.

In the current investigation, HDEP did not differ across treatments ($P > 0.05$). The lack of considerable variation in hen-day egg production suggests that a diet including up to 45% enset corm and potato chips as a replacement for maize could be employed to meet the nutrient needs of layers. Enyenihi et al. (2009) found that replacing maize with 75% cassava tuber meal increased HDEP. Inclusion of sweet potato meal up to 20% as a replacement for maize enhanced HDEP in white leghorn layers compared to 30% and 40% diets, which could be attributed to the effect of anti-nutritional elements at higher levels of potato diets

(Ravindran 1995). According to Saentaweesuk et al. (2000), entire substitution of maize by cassava in layers ration had no effect on output performance. Ladokun et al. (2007) found that layers fed 50% sweet potato meal rations had greater HDEP than those fed solely maize. Afolayan et al. (2013) demonstrated that substituting sweet potato meal for maize had no effect on the health of the layers. Nigussu et al. (2019) found that strata that ingested a higher level of kocho had higher HDEP. Kana et al. (2013) discovered no influence on egg weight or feed conversion in pullets fed 0%, 33%, 66%, or 100% cassava root meal in place of maize. Aderemi et al. (2012) discovered that birds fed diets with more than 25% cassava meal had worse feed conversion. The average daily increase, Hen-day egg output, egg weight, and egg mass of layers fed varied levels of enset corm and potato chips mixed diet were equivalent ($P > 0.05$). The lack of substantial variation in hen-day egg production in the current study suggests that up to 45% MECPC diet as a replacement for maize might be employed to fulfill the nutrient requirements of layers.

# Egg Quality

Except for the egg shell weight, the dietary substitution of enset corm and potato chips had no effect on egg quality attributes. This means that a mixture of enset corm and potato chips could be used in tier rationing instead of maize without impacting egg quality. Except for the egg shell weight ($P < 0.05$); all egg quality characteristics were equivalent ($P > 0.05$) across all treatment groups (Table 5). Aderemi et al. (2012) found that replacing maize with whole cassava meal had a similar effect on both internal and external egg quality metrics. According to Nigussu et al. (2016), the effects of partial substitution of maize with enset corm on egg quality indicators were similar ($P > 0.05$) across all treatment groups. The comparability of egg quality characteristics suggests that maize can be substituted for enset corm in the proportion of white leghorn layers without altering egg quality parameters.

Table 5
Egg quality characteristics of Bovans brown hens fed mixture of enset corm and potato chips

| | Treatments, Mean | | | | | |
|---|---|---|---|---|---|---|
| **Egg quality parameters** | **T1** | **T2** | **T3** | **T4** | **SEM** | **P-value** |
| Sample Egg Weight(g) | $56.74^{b}$ | $57.17^{ab}$ | $58.08^{ab}$ | $58.75^{a}$ | 0.81 | 0.042 |
| Egg Length(mm) | 54.37 | 54.72 | 54.79 | 54.78 | 0.106 | 0.392 |
| Egg Width(mm) | 43.04 | 42.82 | 43.03 | 43.48 | 0.183 | 0.354 |
| Egg shape Index | $79.16^{a}$ | $78.26^{b}$ | $78.52^{b}$ | $79.36^{a}$ | 0.526 | 0.027 |
| Egg yolk Weight(g) | 16.00 | 15.88 | 15.98 | 16.36 | 0.104 | 0.348 |
| Egg Albumin Weight(g) | $34.53^{b}$ | $34.83^{b}$ | $35.65^{ab}$ | $36.17^{a}$ | 0.435 | 0.050 |
| Egg Albumin height(mm) | $7.57^{b}$ | $8.03^{a}$ | $7.98^{ab}$ | $8.06^{a}$ | 0.050 | 0.032 |
| Egg Yolk height(mm) | $17.92^{b}$ | $18.15^{ab}$ | $17.96^{b}$ | $18.36^{a}$ | 0.450 | 0.119 |
| Egg yolk diameter(mm) | 40.12 | 39.39 | 39.68 | 40.07 | 1.490 | 0.867 |
| Egg Shell Thickness(mm) | 0.35 | 0.35 | 0.35 | 0.34 | 5.833 | 0.344 |
| Egg Shell weight(g) | $5.94^{b}$ | $6.11^{ab}$ | $6.04^{b}$ | $6.27^{a}$ | 0.008 | 0.011 |
| Egg Yolk Color (RSP) | $2.44^{a}$ | $2.23^{ab}$ | $2.02^{b}$ | $2.52^{a}$ | 0.038 | 0.041 |
| Haugh unit | 87.49 | 89.94 | 89.40 | 89.67 | 1.692 | 0.166 |
| Egg Yolk Index | 0.45 | 0.46 | 0.45 | 0.46 | 0.006 | 0.836 |

a,b Means within a row with different superscripts differ ($p < 0.05$);T1 = 0% ECPCM; T2 = 15% ECPCM; T3 = 30% ECPCM; T4 = 45% ECPCM as a substitute to maize; SEM = Standard Error of the Mean; *RSP = Roche scale points;

# Conclusion

The conclusion drawn from the discussion above is that by substituting semi-intensive or intensive management systems for the conventional ones, it may be possible to increase the production of both village and commercial chickens. However, it is acknowledged that the issue with village chicken production systems in the tropics is complicated; as a result, in order to effectively address this issue, attention should not be limited to the technical element but rather to all factors that are involved in this production cycle as a whole. Additionally, hen-day egg output was comparable to the level at which potato chips and enset corm can replace corn cost-effectively by up to 30%. As a result, enset corm and potato chips can be used as a substitute for maize in layered rations when maize is in short supply in Ethiopian enset and potato farming regions.

# Declarations

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**Disclosure statement**

The author(s) did not disclose any potential conflicts of interest.

**Author Contributions**

Y. K. conceptualized the idea of the study, curated the data, performed formal analysis and investigation, designed methodology, administered the project, and wrote the original draft. G.W. and T.H. acquired funding, performed writing, paper drafting, and reviewed and edited the manuscript.

**Data availability**

The datasets created and analyzed during the current investigation are available upon reasonable request from the corresponding author.

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