Effect of banana peels as a substitute for white maize grain on laying performances and egg quality of Bovans Brown chickens

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ABSTRACT: The study was conducted to evaluate the effect of replacing white maize grain (WMG) by dried banana peels (DBP) on egg production and egg quality parameters at Poultry Unit, University of Gondar, Ethiopia. A total of 96 Bovans Brown layers (28 weeks old age and initial average body weight of 1.60 ± 0.15 kg) were allocated into four treatments with two replications and each replication had 12 layers. The white maize grain (WMG) portion of the concentrate mixture was substituted by 0, 6, 12 and 18% of DBP for T₁, T₂, T₃ and T₄ treatments, respectively. Feed intake, egg production, egg weight and egg mass were recorded daily. The feed intake was significantly higher for T₄ (108.2 g) compared to T₁, T₂ and T₃ (101.2, 104.1 and 103 g, respectively) diets. A significant difference (P < 0.05) was found between treatment groups in HDEP where T₁ was higher (48.4%) than T₂ (45.4%), T₃ (44.3%) and T₄ (44.1%). Egg weight and egg mass were higher (P < 0.05) in control diet, while, it was constant as inclusion rate of DBP increased. Most of egg quality parameters showed nonsignificant difference among treatments. However, shell weight, shell thickness and yolk colour were higher in DBP containing diets. Yolk weight was significantly lower in T₁ and T₂ than other treatments. Therefore, DBP could be substituted up to 18% as alternative feedstuffs for laying hens DBP without detrimental effect on performance and egg quality traits.

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PUBLIC INTEREST STATEMENT
High feed cost, poor quality and low availability of feed resources are root causes for the poor performance of poultry sector Therefore, improvement of poultry production system through introduction of better feeding strategy is very important. Therefore, replacing cereals and expensive and less available agro-industrial by products by unconventional source of raw materials, which are less exploited by man, is one of the solutions to alleviate this situation and contribute to increased supply of animal products. In this context, fruit by products like banana peels as poultry feed is one of the solutions to halt this situation and contribute for increased supply of animal products. Thus, this research was conducted to determine the effect of different levels of inclusion of dried banana peels as a substitute for wheat maize grain on the egg laying performance and egg quality parameters of Bovans Brown chicken.
1. Introduction
Poverty and food insecurity are widespread in Ethiopia, where approximately 13.2 million people are food insecure and 3.9 million women and children are nutritionally vulnerable (World Bank, 2019). Chicken production, as one part of livestock production, has major contribution to the food security of smallholders in Sub-Saharan African. Ethiopian government promotes meat and egg production in support of poverty alleviation and food security. According to Ethiopian 10 years Development Plan 2021, the projected annual production is planned to increase chicken meat production from 48,000 tons to 106,000 tons and egg production from 2.8 billion to 5.5 billion by the year 2030 to fulfill the demand for domestic consumption. The chicken population is estimated to be 49 million, of which 94.33% are native, 3.21% hybrid and 2.47% exotic breeds (CSA, 2020). In Ethiopian, local chickens kept under the low input-out system constitute a large proportion of the national poultry population. It also contributes approximately 98.5% and 99.2% to national egg and chicken meat production, respectively (CSA, 2018). Despite large poultry population in Ethiopia, the production and productivity of local chicken is affected by poor genetics, feed and nutrition and diseases. Among others, low availability of feed resources, poor quality and high feed cost are root causes that limit the productivity of chicken in sub-Saharan African countries in general and Ethiopia in particular (Mazengia et al., 2012; MOA, 2015; Serkalem et al., 2019). Moreover, small and medium scale poultry production in urban and peri-urban areas largely depend on high quality cereal-grains, used as human food, putting it in direct competition with poultry feed, which leads to increased cost of poultry production (Fowzia et al., 2016; Nigussu et al., 2019). The current low input—low output systems do not match with the current rate of increasing demand for animal source food in the country. There should be a clear direction that intensification of poultry production through improved quality feed supply and nutrition. Thus, finding non-conventional feed resources are urgently needed. The use of fruit by-products like banana peels as poultry feed is one of the solutions to halt this situation and contribute for increased supply of animal products. However, there is inadequate baseline information on the potential use and level of inclusion in poultry diets. Therefore, the aim of this research trial was to determine the effect of partial substitution of white maize grain with dried banana peels on the egg laying performance and egg quality parameters of Bovans Brown chicken.

1. Material and methods

1.1. Experimental site and location
The study was conducted at Poultry unit, University of Gondar, Amhara region, Ethiopia. The university is situated in North of Lake Tana, at about 738 km away from Addis Ababa. Astronomically, the University is located at between geographical coordinates 12.3° to 13.38° north latitudes and 35.5° to 38.3° east longitudes with an elevation of 1422 meters above sea level (masl). The mean annual rainfall ranged from 880 mm to 1772 mm and the mean minimum and maximum temperatures are 10 °C and 44.5 °C, respectively (National Metrology Agency (NMA), 2011; Tizazu et al., 2019).

1.2. Experimental design and feed formulation
A total of 96 bovans brown layers (28 weeks old age and average body weight of 1.60 ± 0.15 kg) were obtained from poultry farm, University of Gondar, Amhara region, Ethiopia. The experimental layers were assigned into four dietary treatments with two replications and each replication had 12 layers. The white maize grain (WMG) portion of the diets was replaced by 0, 6, 12 and 18% of dried banana peels (DBP), representing T1, T2, T3, and T4. Feed ingredients were collected from local market in raw form. Experimental diets were prepared from white maize grain, wheat grain, noug-seed cake, soybean grain, dried banana peel, vitamin premix, lysine, bone mill, limestone and salt.
Adequate amount of banana peel was collected from local market, cafes and juice shops. The collected banana peels were prepared by chopping the peels, dried for one day in a direct sun light and an extra 3 days under shade with good ventilation by sparsely spreading on clean plastic sheets. Then, the peels were ground to pass through 5 mm sieve and stored until it required for experimental diet formulation. The proximate compositions of banana peels and other feed ingredients are shown in Table 1.

### 1.3. Management of experimental layers

Before the start of the actual experiment, each pen, feed trough, water trough and egg laying nests were thoroughly cleaned, washed and disinfected. Ninety six bovans brown layers (28 weeks old age and average body weight of 1.60 ± 0.15 kg) were obtained among layers kept for egg production at University of Gondar poultry farm and used in this study. The experimental trial was lasted for three months (12 weeks). Experimental layers were kept on deep floor house with a 2 m x 2.5 m floor space. The experimental pens were furnished by wood shaving. Experimental layers were provided water with vitamin premix (15 mm vitamin premix in 10 ltr water) after one week adaptation period. Then, experimental layers were vaccinated against disease and medication provided using broad spectrum antibiotics. Experimental feed was provided to the layers two times daily through ad libitum.

### 1.4. Chemical analysis of experimental feeds

The treatment diets were formulated by taking the nutrient composition of each ingredients and balancing with nutrient requirement of layer. The treatment feeds were formulated to be iso-caloric and iso-nitrogenous with approximately 16–17% CP and 2800–2900 kcal/kg DM ME recommended by NRC (1994) for layer chicken. The chemical composition of the experimental feeds is presented in Table 2. The experimental rations were formulated by using feed win interactive software and excel based on layer metabolic energy and crude protein requirement. The chemical composition of experimental feeds was determined according to AOAC (1990).

### 1.5. Data collection

Body weight gain, feed intake, feed conversion ratio and survival rates were recorded to evaluate the inclusion of banana peels as a substitute for white maize grain on laying performances and egg quality parameters. Feed consumption was determined by subtracting the amount of feed refused from the amount feed offered on DM basis. Body weight measurement was taken on weekly basis. The mean feed conversion ratio was measured as the amount of feed consumed per unit body weight gain as shown below. Feed conversion efficiency (FCE) was determined by dividing the egg mass with the weight of feed consumed.

\[
FCE = \frac{\text{Daily feed consumed (g)}}{\text{Daily egg mass (g)}}
\]
Hen day egg production was determined using the following formula given by North (1978), Feed efficiency per dozens of eggs by Ahmad et al. (2010), egg production was calculated by total number of eggs produced by hen divided by total number of hens live.

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

The sample eggs were individually weighed, marked and broken on flat tray and then to measure the egg shell weight by using sensitive balance. The egg shell thickness was measured on individual eggs at the middle, large end and small end of the shell by using a micrometre gauge and the mean value was taken as the thickness of each egg (Ajuwon et al., 2002). The yolk weighed was measured by sensitive balance. Albumen weight was calculated by subtracting yolk and shell weight from total egg weight. The albumen height and yolk height of each egg were measured with a tripod micrometer (Safaa et al., 2008b). Yolk color was measured using roach color fun. (Bovšková et al., 2014). Haugh unit measures the quality of the egg and it was calculated using the following formula given by Haugh, (1937).

\[
\text{HU} = 100 \log_{10} (h + 7.57 - 1.7w0.37)
\]

Where; \( \text{HU} \) = Haugh unit

\( h \) = albumen height (mm)

\( w \) = weight of egg (g).

1.6. Statistical analysis

Data from the feeding trials such as feed intake, feed conversion efficiency, body weight gain egg production and egg quality parameters were subjected to analysis of variance (ANOVA) using the General Linear Model of SAS (SAS, 2009). When treatment effect was found significant, least significant difference (LSD) were employed to detect differences among treatment means. The following model used for statistical analysis was:

\[
Y_{ij} = \mu + t_i + e_{ij}
\]
Where $Y_{ij} = $ the response variable

t = treatment effect

$\mu = $ over all mean

$\varepsilon_{ij} = $ random error

2. Results and discussion

2.1. Growth performance of chickens

The effects of inclusion of different levels of banana peels on growth of chickens are presented in Table 3. The current study showed that there was no significant difference ($P > 0.05$) among treatment groups for initial body weight, final body weight and average daily gain. Previous study by Araya et al. (2021) also reported similar results. The mean daily feed intake was higher ($p < 0.0001$) in DBP 18% group as 108.2 g/d compared to DBP0% as 101.2 g/d and other treatment groups. The result of present study is in line with Blandon et al. (2015) and Araya et al. (2021). They reported that there was no significant differences ($P > 0.05$) in body weight gain between the treatment groups fed on enzyme-free banana peel compared to control group. However, Abel et al. (2015) also reported a decreasing trend in final live body weight of chickens feed with increasing levels of the banana peel meal (10%, 20% and 30%). Atapattu and Senevirathne (2013) and Omole et al. (2008) also observed that increasing levels of banana peel meal had significantly affected body weight gain of broiler chickens. Total feed intake of experimental layers were significantly influenced ($p < 0.05$) by the level of dried banana peels. The total feed intake of layers fed DBP18% in diet was significantly higher ($p < 0.05$) than DBP0%, DBP 6% and DBP 12%.

The present result showed that the feed conversion ratio did not show significant difference ($P > 0.05$) among the treatment groups. The feed conversion ratio recorded in the present study is consistent with the report of Atapattu and Senevirathne (2013). They reported that no significant ($P < 0.05$) difference in the feed conversion ratio up to 30% of banana peel in the broiler diet. However, the current result does not agreed with Blandon et al. (2015) who reported increased feed conversion ratio up to 45% of yellow corn with dried banana peels in the broilers’ diets. In contrast to these findings, Abel et al. (2015) also reported that the feed efficiency ratio decreased.

Table 3. Effect of dried banana peels on growth traits of Bovan Brown chickens

| Parameters                          | Treatments   | $T_1$ | $T_2$ | $T_3$ | $T_4$ | SEM | p value |
|-------------------------------------|--------------|-------|-------|-------|-------|-----|---------|
| Initial body weight (g)             |              | 1507  | 1473  | 1503  | 1484  | 14.58 | 0.62    |
| Final body weight (g)               |              | 1646  | 1592  | 1612  | 1587  | 19.65 | 0.34    |
| Body weight gain (g/day)            |              | 1.5   | 1.3   | 1.2   | 1.0   | 0.165 | 0.40    |
| Daily feed intake (g/ day)          |              | 101.2$^c$ | 104.1$^b$ | 103$^{bc}$ | 108.2$^a$ | 0.947 | 0.01    |
| Total feed intake (g)               |              | 9012.5$^c$ | 9287$^{bc}$ | 9179$^{bc}$ | 9642$^a$ | 78.4  | 0.01    |
| Feed conversion ratio (g feed/g egg)|              | 4.4   | 4.5   | 4.9   | 5.1   | 0.225 | 0.11    |

$^a$ $^b$ $^c$ "raw means with different superscripts are significantly different, $T_1 = $ Treatment one, $T_2 = $ Treatment two, $T_3 = $ Treatment three, $T_4 = $ Treatment four"
as the level of banana peels meal (10, 20, and 30%) inclusion increased in the broilers treatment rations.

2.2. Egg laying performance of chickens
The egg production of layers fed dried banana peels are presented in Table 4. The present results showed that there was nonsignificant effect (P > 0.05) in the mean number of eggs produced per hen between treatment groups. Florou-Paneri et al. (2001) also reported that the addition of 6% dried citrus pulp in laying quail diets did not result in reduction of egg production. There was a significant difference in HDEP between the treatment groups. T1 was significantly (P < 0.05) higher in HDEP as compared to T3 and T4. However, T3 and T4 treatments were the same to each other. In the current study, HDEP indicated a decreasing trend with increasing level of DBP in the layer diet. In agreement with the present study, Anaeto and Adighibe (2015) and Araya et al. (2021) also reported a decreasing trend in HDEP of layer fed with an increasing level of cassava root meal diets substituting maize. This might be attributed to the lower level of essential amino acids in dried banana peels of the layer diet. According to Emaga et al. (2011), banana meal contains the lower level of lysine, methionine and tryptophan. Previous study of Al-Betawi (2005) also reported positive correlation between methionine and lysine levels in the diets and egg production.

There was also a significant difference (P < 0.05) between treatment groups in mean egg weight and egg mass. The mean egg weight and egg mass of layers fed DBP0% was significantly higher (P < 0.05) than DBP6%, DBP12% and DBP18% (Table 4). This might be due to deficiency of methionine in dried banana peel than white maize grain than WMG, as previous study reported that methionine has a large influence on egg size (Waldroup & Hellwing, 1995). The present result on egg mass obtained in this study is consistent with Anaeto and Adighibe (2015) who reported significantly lower egg mass in layers fed diet containing cassava root meal beyond 50% as a replacement for maize. Haitham (2010) in his study also reported that layers fed diet with low CP content laid fewer eggs and had lower egg mass as compared with diets consisting higher CP. The results of the present study were also in line with the previous study of Emaga et al. (2011) who confirmed that the banana meal was found to be deficiency in lysine, methionine and tryptophan.

2.3. Egg quality parameters
The egg geometric traits of experimental layers are presented in Table 5. Majority of the external and internal egg quality parameters did not show significant difference between treatments, except shell weight, shell thickness, yolk weight and yolk color. The egg shell weight and thickness were significantly (P < 0.05) lower in DBP0% than DBP6%, DBP12% and DBP18%. The layers fed dried banana peels showed a significant improvement in egg shell weight and thickness than the control group. Previous report of Zita et al. (2009) also indicated that difference in egg shell thickness was influenced by feed quality especially in minerals and vitamins. Haftu et al. (2014) in their study also reported that similar shell weight for white leghorn layers fed ration containing up to 30% dietary levels of malted barley replacing maize. The mean yolk weight was significantly (P < 0.05) higher for experimental layers fed 12% DBP and 18% DBP than 6% DBP and control group. Control group (DBP0%) had significantly lowest (P < 0.0016) mean yolk colour compared to other treatment groups. These implied that yolk colour was improved (P < 0.05) as the inclusion rate of DBP increased in the layer diets. Meseret et al. (2011) stated that yolk colour was increased with an increasing level of Ground Prosopis juliflora Pod in the ration, while it was significantly higher (P < 0.05) at 30% than the remaining treatment groups. The higher yolk colour in DBP than the WMG attributed to the presence of certain pigment particularly xanthophyll’s in DBP.

2.4. Partial budget analysis
The result obtained from partial budget analysis showed that feed cost decreases as increases as the level of dried banana peels in the diet containing 6%, 12% and 18% dried banana peels. Previous study of Araya et al. (2021) also showed that the cost of feed decreased with the increase
Table 4. Effects of dried banana peels on egg laying performance of Bovans Brown chickens

| Production performance traits | $T_1$ | $T_2$ | $T_3$ | $T_4$ | SEM | p value |
|-------------------------------|-------|-------|-------|-------|------|---------|
| Total egg production/ hen     | 43.5  | 40.8  | 39.9  | 39.7  | 1.35 | 0.38    |
| Egg weight (g)                | 58.5$^a$ | 57.4$^b$ | 57.1$^b$ | 57.2$^b$ | 0.32 | 0.02    |
| HDEP (%)                      | 48.4$^a$ | 45.4$^c$ | 44.3$^b$ | 44.1$^b$ | 1.27 | 0.04    |
| Egg mass (g/h/d)              | 28.4$^a$ | 26.5$^b$ | 25.6$^b$ | 25.4$^b$ | 0.76 | 0.02    |

$^{a, b, c}$ Row means with different superscripts are significantly different. HDEP = Hen day egg production, $T_1$ = Treatment one, $T_2$ = Treatment two, $T_3$ = Treatment three, $T_4$ = Treatment four.
of proportion of banana peels in the ration. The current study showed that the replacement of white maize grain with 18% dried banana peels (T₄) gave higher net return while the remaining treatments were ranked T₂ > T₃ > T₁ (Table 6). The least benefit was obtained from T₂ (6% dried banana peels); these results due to high production cost. The change in total variable cost in all treatment groups was negative but the change in net return was positive for T₄. The highest net return for T₄ (18% dried banana peels) in the current study is due to lower cost of the dried banana peels as compared to white maize grain. This means that the cost of egg production decreases with increasing dried banana peels as an energy ingredient up to 18 % dried banana peels (T₄) level of replacement of white maize grain. Moreover, the cost of conventional basal energy feed-stuffs, particularly maize grain in livestock feeding, has contributed to the low level of animal production. Medegu et al. (2011) reported highest cost per kg feed in maize-based diet compared to sorghum based diets. Silas et al. (2014) also showed that there is lowered feed cost when an

Table 5. Effects of dried banana peels on egg quality traits of Bovans Brown chickens

| Egg quality traits | T₁ | T₂ | T₃ | T₄ | SEM | p value |
|--------------------|----|----|----|----|-----|--------|
| Egg weight (g)     | 58.9 | 59.5 | 60.6 | 58.5 | 0.56 | 0.304 |
| Egg length (mm)    | 56.1 | 56.5 | 59.7 | 58.9 | 0.58 | 0.056 |
| Egg width (mm)     | 43.3 | 43.3 | 43.5 | 44.3 | 0.48 | 0.663 |
| Shell weight (g)   | 6.6₃ | 8.3₃ | 7.7₃ | 7.₈₃ | 0.20 | 0.039 |
| Shell thickness (mm)| 0.32ₖ | 0.₄₁ₖ | 0.₄₅ₖ | 0.₄₄ₖ | 0.02 | 0.039 |
| Albumen weight g)  | 36.3 | 35.9 | 36.0 | 33.8 | 0.62 | 0.210 |
| Albumen height (mm)| 4.8  | 6.2  | 6.2  | 6.1  | 0.43 | 0.428 |
| Yolk weight (g)    | 15.₆₃ | 15.₃₃ | 16.₉₃ | 16.₉₃ | 0.18 | 0.010 |
| Yolk height (mm)   | 16.₃ | 16.2 | 16.5 | 15.₈ | 0.16 | 0.2ₘ₉ |
| Yolk colour        | 3.₄ₖ | 4.₇ₖ | 4.₈ₖ | 4.₇ₖ | 0.09 | 0.001 |
| Haugh unit         | 66.2 | 78.₅ | 77.₆ | 77.₉ | 4.₁₉ | 0.₄₃₄ |

ₐ, ₖ; *row means with different superscripts are significantly different, T₁ = Treatment one, T₂ = Treatment two, T₃ = Treatment three, T₄ = Treatment four

Table 6. Economics of feeding dried banana peels to Bovans Brown layers

| Parameters                  | T₃              | T₂              | T₄              | T₅              | T₆              | T₇              | T₈              | T₉              | T₁₀             |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Total feed consumed/Treatment (kg) | 216.3           | 222.9           | 220.3           | 231.₄           |                  |                  |                  |                  |                  |
| Total feed cost/Treatment (birr) | 2397.₇         | 2323.₅          | 2151.₈          | 2108.₄          |                  |                  |                  |                  |                  |
| Total egg produced (No.)    | 104₅             | 980             | 958             | 952             |                  |                  |                  |                  |                  |
| Total return (birr)         | 3135             | 2940            | 287₄             | 285₆             |                  |                  |                  |                  |                  |
| Net return (birr)           | 737.₃            | 616.₅           | 722.₂            | 747.₆            |                  |                  |                  |                  |                  |
| Change in total return      |                  | -195            | -261            | -279            |                  |                  |                  |                  |                  |
| Change in total variable cost |                  | -7₄.₃           | -24₅.₉          | -2₈₉.₃           |                  |                  |                  |                  |                  |
| Change in net return (birr) |                  | -120.₇          | -1₅.₁           | 10.₃            |                  |                  |                  |                  |                  |
| MRR (%)                     |                  | 1.₆₂            | 0.₆₆₁           | -0.₀₃₅          |                  |                  |                  |                  |                  |

MRR: marginal rate of return; Birr is Ethiopian currency; 1 USD = 52 Ethiopian Birr; the price of the egg during the experiment at local market was 3 birr/egg; kg: kilogram; No.: number; %: percent; T₁: Ration containing 0% DBP; T₂: Ration containing 6% DBP; T₃: Ration containing 12%DBP; T₄: Ration containing 18% DBP as substitute for WGM.
alternative feed ingredient is used in place of the conventional feedstuffs. Moreover, Abel et al. (2015) stated that the inclusion of treated banana peel meal in the broiler rations were positively leads to cost reduction in feed purchase thus a lowered cost of production and a better feed conversion ratio. Therefore, under the condition of the current experiment, dried banana peels can replace white maize grain in T4 (18% dried banana peels) is profitable and economically feasible because of relatively lower cost. Thus, dried banana peels can be substituted for white maize grain up to 18 % (T4) due to its positive effect on profitability without any detrimental effect on egg quality and health of hens.

3. Conclusion
Use of dried banana peels in the concentrate mixture of layer diet resulted in better chicken performance. In the current study, the economic return in terms of partial budget analysis showed that the feed cost was decreased as increased level of DBP in the layer ration. Since the lowest cost of egg production was recorded as the level of DBP is increased, T4 (18%DBP) was showed high profit than the other treatments. Thus, DBP can replace up to 18% of white maize grain economically without affecting body weight and egg quality of chicken. This implies that there is great opportunity in utilizing banana peels as a substitute for white maize grain.

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