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Research paper

CGM (Corn Gluten Meal) Substitution in Feed Conversion, Productivity, and Egg Yolk Color in Laying Hens

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Abstract

Egg is a source of animal protein which is cheap and it is very easy to get for consumption. Hence, the quality of egg becomes one of the factors that must be considered in laying hen cultivation. One of the important factors is feeding. Feeding with CGM (Corn Gluten Meal) substitution to laying hens is conducted to know the influence of CGM to the number of eggs, the weight of eggs, feed conversion, and egg-yolk colour. This research was conducted in June-July 2022 in laying hen farming located in Pasuruan, East Java. This research is conducted by dividing 40 strain laying hens of Isa Brown into 4 treatment groups, so each group consists of 10 hens. The treatment used is by feeding them with 4 different CGM concentration, namely P0 (CGM 0%), P1 (CGM 5%), P2 (CGM 10%), and P3 (CGM 15%). The obtained data was analysed by using Analysis of Variance (ANOVA). The result of the research shows that CGM substitution does not influence to the number of eggs, but influence the weight of eggs, feed conversion, and egg-yolk colour. The average of the heaviest egg is obtained at treatment group given CGM 10% of feed composition, the average of the littlest feed conversion at group treatment given CGM 15%, and egg yolk colour of laying hens with CGM 15% get the biggest score 13 and the average is 12,33.

Keywords: *CGM, Chicken Productivity, Egg Yolk Colour, Food Conversion, Lay Hens*

1. Introduction

Isa Brown is a medium-type laying hen known for several advantages that make it a leading choice in egg-laying poultry farming. These advantages include high egg productivity, appropriate egg weight, low feed conversion ratio (FCR), high viability, and a long laying period. Additionally, Isa Brown chickens are characterized by high uniformity, evenly distributed adult sex ratio, strong disease resistance, and good resilience to tropical climates (M. Rasyaf, 2005). Isa Brown hens start laying eggs at 18 weeks of age with an initial egg weight of 43 g, reach a production peak of 95%, with a total egg yield of around 351 eggs per hen, and an average egg weight of 63.1 g/egg (Layers, 2009).

In commercial poultry farming, feed accounts for the largest production cost component, ranging from 60% to 70% of total expenses. Therefore, it is essential for farmers to use feed that is not only cost-effective but also of high quality to meet the nutritional needs of chickens for growth and egg production. While many farmers still rely on commercial feed, the increasing price of feed has necessitated the development of self-formulated rations (Setyono et al., 2013). Feed components such as proteins, fats, carbohydrates, vitamins, and minerals are digested and converted into absorbable materials to support life, growth, feather development, egg production, and fat storage (Mulyantini, 2014; Pond et al., 2004).

One promising alternative feed ingredient is Corn Gluten Meal (CGM), a by-product derived from corn starch separation. CGM is intensely yellow due to its high xanthophyll content and serves as a natural yolk pigment enhancer (Umiyasih & Wina, 2008). CGM contains less fiber than Corn Gluten Feed (CGF), and with more than 20% protein content, it is an excellent source of bypass protein (rumen undegradable protein), making it highly suitable for poultry poultry (Murni et al., 2008) (Tangendjaja & Wina, 2007). However, few studies have compared the effectiveness of CGM with other protein sources such as soybean meal or fishmeal, particularly regarding feed conversion efficiency, egg quality, and consumer preferences for yolk color. Previous studies such as those by Murni et al. (2008) and Tangendjaja & Wina (2007) have demonstrated CGM's potential, but have not explored in depth how CGM may address gaps in economical and high-quality poultry feed formulation.

Feed conversion is one of the main indicators of feed utilization efficiency. It is calculated as the ratio of feed intake to egg mass output (I. M. Rasyaf, 2011; Fidianti et al., 2023). Feed conversion is influenced by genetic factors, feed form, environmental temperature, feed intake level, chicken body weight, and feed nutrient content conversion (Siregar et al., 1980). According to Isapoultry (2023), the feed conversion ratio of Isa Brown laying hens is 2.13, while Sterling et al. (2003) reported that medium-type laying hens have a feed conversion ratio of about 2.08.

Egg size or egg weight is also a vital parameter for evaluating the productivity of laying hens. Typically, chicken eggs weigh between 40–80 g per egg, and this is influenced by ovum size, laying intensity, and the nutrient content in the ration (Campbell, 2003). Factors such as strain, age at first laying, environmental temperature, and pullet size in the flock also affect egg weight (North & Bell, 1990). Interestingly, while an increase in dietary metabolizable energy does not significantly affect egg weight, increasing protein content from 12% to 18% in the feed can improve egg weight.

Yolk color is another critical aspect, particularly due to consumer preference, which is highly influenced by visual characteristics. Yolk color is determined by the type of pigment present in the feed, especially xanthophylls. Consumers generally prefer golden yellow to orange yolks, corresponding to a score of 8 to 14 on the Roche yolk color fan (Winarno, 2002; Wiradimadja et al., 2010). In this context, CGM, with its rich xanthophyll content, holds significant potential in enhancing consumer-preferred yolk coloration; however, more comprehensive studies are needed to confirm the consistency of CGM's effects on yolk color compared to synthetic pigments or other natural additives like marigold or paprika.

Considering the importance of feed efficiency, egg number and weight, and yolk quality, this study aims to investigate the effect of Corn Gluten Meal (CGM) substitution in feed on egg production, egg weight, feed conversion, and yolk color in Isa Brown laying hens. This research also seeks to address gaps in existing literature that have not explicitly examined the strategic role of CGM in modern egg production systems, particularly in terms of cost efficiency and consumer-preferred egg quality.

2. Method

The design used in this study is a complete random design (RAL), The treatment used is as follows.

P0 = feeding chickens with a CGM concentration of 0% (no CGM)
P1 = feeding chickens with a CGM concentration of 5%
P2 = feeding chickens with a CGM concentration of 10%
P3 = feeding chickens with a CGM concentration of 15%

The sample used in this study is laying hens from farms in Purwosari. The sample size to be used is 40 chickens which will be divided into 4 treatment groups, each treatment is 10 heads.

Daily Measurement of Weight, Consumption and Conversion of Feed Chickens are weighed with a K1-A Ming Heng® digital scale with an accuracy of 0.1 g. The amount of feed given and leftover feed is also calculated after separating with fecal contaminants on the feeder tray. Meanwhile, the feed conversion is calculated by the formula: FCR= F / (Wt – W0), where FCR: feed conversion ratio; F: weight of feed eaten (g); Wt: chicken weight at the end of the period (g); W0: weight of the chicken at the beginning of the period (g). Feed conversion was evaluated weekly to find out the development trend during the study (Listyasari et al., 2022).

The number of eggs in this study is the number of eggs produced by each group of laying hen samples after being treated. The egg weight in this study was obtained from the eggs of each group of laying hen samples weighed using a balance/scale. Feed conversion or ration conversion is carried out by comparing the amount of feed or ration consumption with the weight of the eggs.

$$\text{Feed conversion} = \frac{\text{Total feed consumption}}{\text{Egg weight}}$$

Feed consumption = amount of feed given – remaining feed

The color of the yolk consists of pale yellow to orange. In this study, the color of the yolk will be tested using a egg yolk colour fan to find out the difference in egg quality.

The research was carried out in June – July 2024 at a laying hen farm located in Purwosari, Lawang, Pasuruan, East Java. Chicken feed consists of a mixture of corn, bran, concentrate (CP 124), and CGM with CGM concentrations of 0%, 5%, 10%, and 15%. The composition of the feed is as follows:

P0 = 2500g corn + 750g bran + 1750g concentrate
P1 = 2375g corn + 750g bran + 1750g concentrate + 125g CGM
P2 = 2250g corn + 750g bran + 1750g concentrate + 250g CGM
P3 = 2125g corn + 750g bran + 1750g concentrate + 375g CGM

This study used a total of 40 Isa Brown laying hens in the laying phase, aged 21 to 24 weeks, which were randomly assigned into four treatment groups, with 10 chickens in each group. This sample size was determined based on previous similar experimental studies in poultry nutrition, where group sizes of 8–12 hens per treatment are commonly applied to detect meaningful differences in production performance variables such as egg weight, feed conversion ratio, and yolk pigmentation (Murni et al., 2008) (Tangendjaja & Wina, 2007). With 10 hens per group and controlled experimental conditions, this design provides sufficient statistical power for detecting treatment effects while maintaining practicality in management and observation.

Each group received different levels of CGM substitution in their feed ration. The experimental period began after a six-day adaptation phase and continued for 22 consecutive days of data collection. During this period, the daily amount of feed offered and feed leftover was weighed using a digital balance to determine the actual feed consumption per group. Eggs laid by the hens were collected and counted daily to determine egg production, and their individual egg weights were measured using an analytical scale. To assess yolk color, the Roche Yolk Color Fan (RYCF) scale was used as a standardized tool.

The data obtained—including total egg production, average egg weight, feed consumption, feed conversion ratio (FCR), and yolk color score—were subjected to statistical analysis using Analysis of Variance (ANOVA) to determine the significance of differences between treatment groups. If significant differences were found, post-hoc tests (such as Duncan's Multiple Range Test) were planned to identify specific group differences. Statistical significance was set at $p < 0.05$.

3. Results and Discussion

1. Number of Eggs

The average number of eggs produced by Isa Brown laying hens over 22 days can be seen in Table 1 below.

Table 1: Average Number of Eggs and Standard Deviation (SD) of Isa Brown Laying Hens

Treatment	Average Number of Eggs (Eggs) ± Standar Deviation
P_0	9.4545 ± 0.7385
P_1	9.3636 ± 0.7267
P_2	9.5909 ± 0.5032
P_3	9.5455 ± 0.5958

Based on Table 1, it can be seen that the average number of eggs obtained in treatment 2 (10% CGM substitution) was 9.5909 and followed by treatment 3 (15% CGM substitution) of 9.5455 and treatment 0 (0% CGM substitution) of 9.4545. Meanwhile, the number of eggs in treatment 1 (CGM substitution 5%) had the least average egg yield of 9.43636.

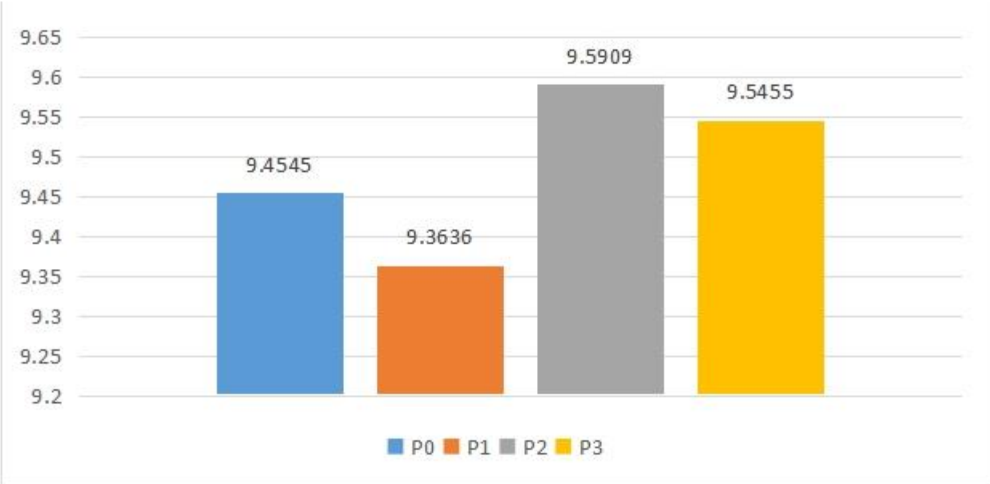

Fig. 1: Egg Flat Bar Diagram According to Treatment

The bar diagram above shows the average number of eggs in laying hens that are treated for 22 days. In the graph, the average number of eggs in treatment 2 has a close proximity to treatment 3 and higher when compared to the control that is not substituted with CGM and treatment 1 with CGM 5%. The ANOVA (Analysis of Variance) calculation with a confidence level of 95% also showed that there was no significant effect on the number of eggs between the CGM treatments P0, P1, P2, and P3.
Based on the results of ANOVA according to Table 1 above, it produces an F calculation of 0.532 and a significance of P-value of 0.662 (greater than the significance level of 5%), so that all treatments are taken to give the average response result of the same number of eggs. This means that CGM treatment does not have a different impact on the average result of the number of eggs produced.
Isa Brown laying hens have an egg-laying period at the age of 18-80 weeks, viability is 93.2%, FCR 2.14, peak production reaches 95%, the number of eggs is 351 eggs, the average egg weight is 63.1 g/egg. The beginning of laying eggs is at the age of 18 weeks with an egg weight of 43 g. Egg weight begins to increase at the age of 21 weeks to 36 weeks and is relatively stable at the age of 50 weeks (Isa Brown Commercial Layers, 2009).

2. Egg Weight

The average weight of eggs produced by Isa Brown chickens after 22 days of treatment is listed in Table 2 below:

Table 2: Average Egg Weight and Standard Deviation (SD) *of Isa Brown Laying Hens*

Treatment	Average Egg Weight (grams) ± Standar Deviation
P0	57.5227 ± 1.3225
P1	57.3573 ± 1.2861
P2	58,755 ± 0.8503
P3	58,605 ± 1.0453

Based on Table 2, it can be seen that the largest average egg weight was obtained in treatment 2 (10% CGM substitution) of 58.755 grams, followed by treatment 3 (15% CGM substitution) of 58.605 grams and treatment 1 (5% CGM substitution) of 57.3573 grams. Meanwhile, the weight of eggs in the control treatment (0% CGM substitution) was 57.5227 grams, higher than treatment 1, but lower than the results of treatment 2 and treatment 3. In general, treatment 2 and treatment 3 resulted in a higher average egg weight than the control treatment.
The bar diagram above shows the average egg weight in chickens that were treated for 22 days, that the average egg weight in treatment 2 was the highest compared to the results of other treatments. Treatment 2 and treatment 3 had higher results when compared to the results of the control treatment that was not substituted with CGM. Treatment 1 obtained the lowest egg weight results compared to other treatments, including control treatment that was not substituted with CGM.
The average egg weight produced by each laying hen in each treatment group in Table 2 weighed above 57 grams with the largest average egg weight in the P2 treatment group (10% CGM substitution) which was 58.755, heavier than the group without P0 treatment which resulted in an average egg weight of 57.5227 grams. The results of the ANOVA calculation showed that with a confidence level of 95%,

there was a significant influence between each treatment group and egg weight. It shows that the CGM content in feed can affect egg weight.
Based on the ANOVA results according to Table 2 above, it produces a calculated F of 9.220 and a significance of P-value of 0.000 (less than the significance level of 5%), so that the treatment gives different egg weight average response results. This means that CGM treatment has a different impact on the average weight of the eggs produced.
Egg size/egg weight can be interpreted as the size of the egg expressed in weight. Normally chicken eggs weigh between 40-80 g/egg (Campbell et al., 2003). According to Anggorodi (1995), the factors that affect the size of the egg are the level of sexual maturity, protein and sufficient amino acids in the ration. Another factor is the calcium and phosphorus content in the ration.

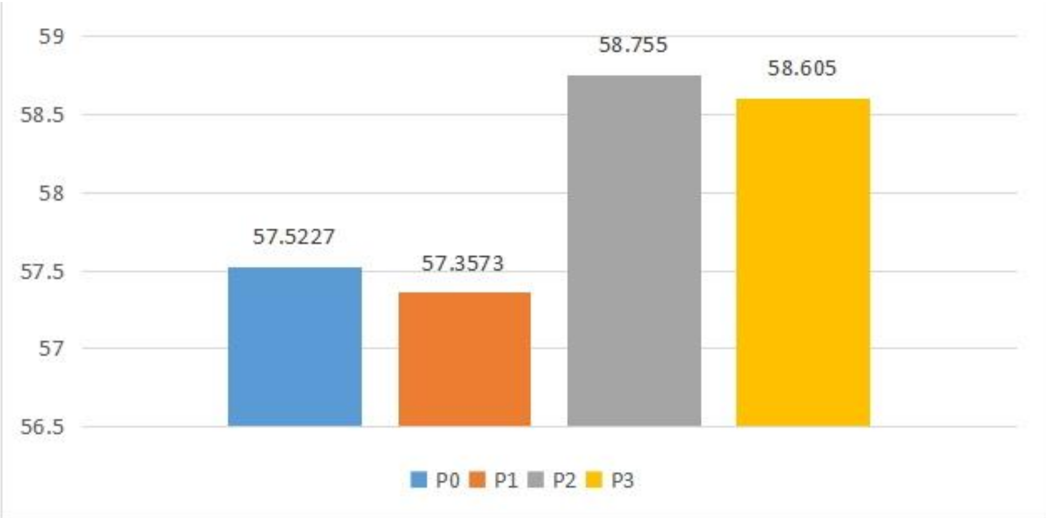

Fig. 2: Diagram of the average bar weight of eggs according to treatment

3. Feed Conversion

The average feed conversion produced by Isa Brown laying hens for 22 days can be seen in the following Table 3.

Table 3: Average Feed Conversion and Deviation Standards (SD) of Isa Brown Laying Hens

Treatment	Average Feed Conversion (grams) ± SD
P0	2.0975 ± 0.0526
P1	2.1215 ± 0.0489
P2	2.0413 ± 0.0398
P3	2.0374 ± 0.04

Based on Table 3, the average feed conversion was the smallest in treatment 3 (15% CGM substitution) of 2.0374 grams, followed by treatment 2 (10% CGM substitution) of 2.0413 grams and treatment 1 (5% CGM substitution) of 2.1215 grams. Meanwhile, the feed conversion at treatment 0 (0% CGM substitution) was 2.0975. In general, treatment 3 and treatment 2 yielded smaller results than the control treatment. While treatment 1 got greater results than control treatment.

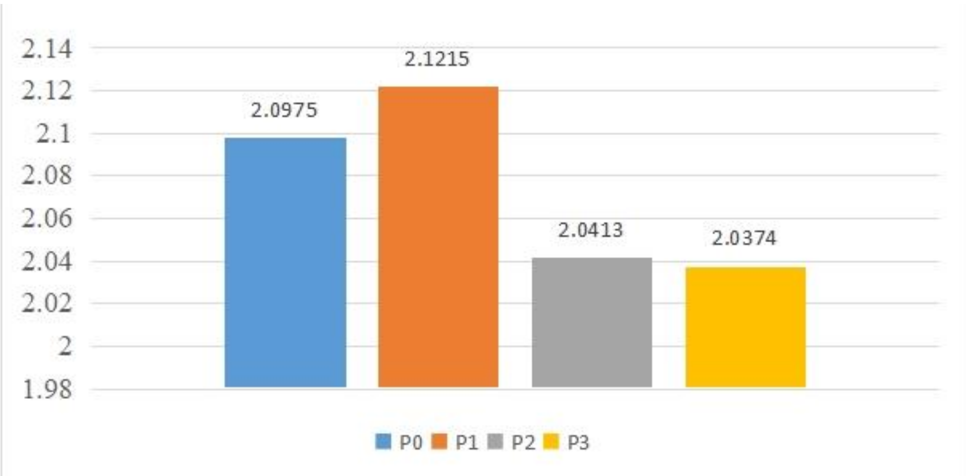

Fig. 3: Diagram of the Flat Bar of Feed Conversion by Treatment

The bar diagram above is the average conversion of Isa Brown laying hen feed at 22 days of treatment. The average conversion rate of P1 feed is higher than that of P0 which is not substituted by CGM. Meanwhile, P0 is higher than P2 and P3. P2 and P3 gave better results than P0 and P1. But P1 is no better than P0.
Based on the data obtained during the study, the average feed conversion in Table 3 shows that the P3 treatment group (CGM substitution 15%) produces the smallest feed conversion value of 2.0374. This shows that chickens in the P3 treatment group use feed for egg production efficiently, which can be seen from the number and weight of eggs produced. The results of the ANOVA calculation showed that there was a significant influence between treatment groups on feed conversion.

Based on the results of ANOVA according to Table 3 above, it produced an F calculation of 18.354 and a significance of P-value of 0.000 (less than the significance level of 5%), that the treatment gave different average feed conversion response results. This means that CGM treatment has a different impact on the average feed conversion results.

The feed conversion value for laying hens is between 2.0 – 2.2 and the smaller the feed conversion value, the more efficient the chicken is in utilizing feed to produce eggs (Prawitya et al., 2015). According to Risnajati (2014), which can affect the feed conversion value includes cage environmental conditions, maintenance management including feeding management, egg production and daily feed consumption.

4. Egg yolk color

The average color of the yolk produced by Isa Brown laying hens for 22 days as listed in Table 4 below:

Table 4: Average Color of Isa Brown Laying Hen Egg Yolk

Treatment	Average Egg Yolk Color
P0	8,25 ± 0,44
P1	9,95 ± 0,23
P2	11,00 ± 0,11
P3	12,33 ± 0,48

Based on Table 4, the color of the yolk in treatment 3 (CGM substitution 15%) produced the largest value. The yolk yield of treatment 3 was greater than that of treatment 0 (0% CGM substitution), treatment 1 (5% CGM substitution), and treatment 2 (10% CGM substitution). In general, CGM treatment gives higher results compared to control treatment.

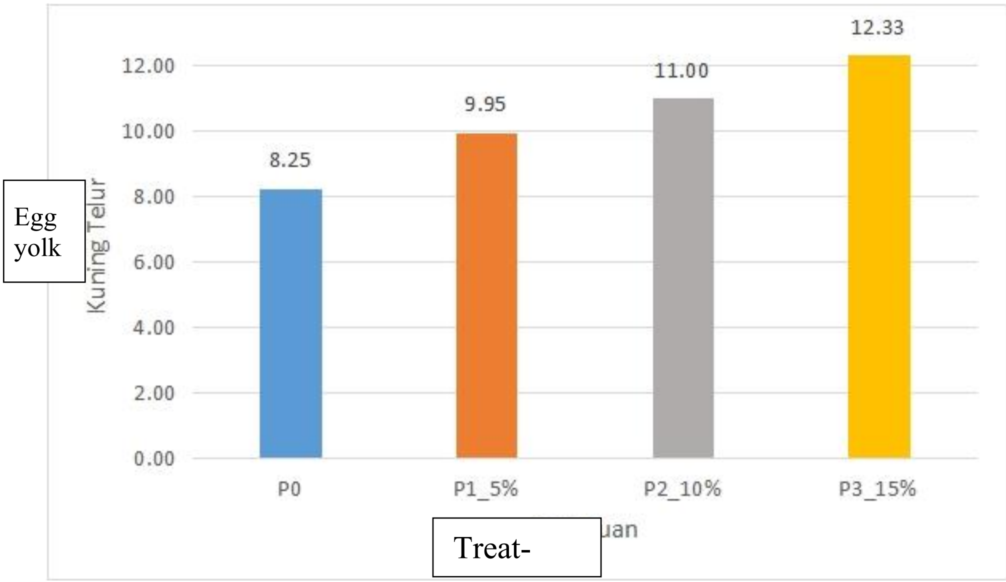

Fig. 4: Diagram of the Egg Yolk Color Flat Bar According to Treatment

The bar diagram above shows the average color of the yolk in laying hens that were treated for 22 days. In the figure, it can be seen that the average color of the yolk in treatment 3 (CGM substitution 15%) is the highest, followed by treatment 2 (CGM substitution 10%), treatment ! (5% CGM substitution), control treatment (no CGM administration). This result shows that the higher the percentage of CGM substitution, the greater the egg yolk color score. Based on the ANOVA results according to Table 4 above, it produces an F calculation of 965.842 and a significance of P-value of 0.000 (less than the significance level of 5%). This means that CGM treatment has a different impact on the average color of the yolk produced.

Egg yolks have a variety of colors, ranging from pale yellow to orange. Egg yolks contain pigments belonging to the carotenoid group, namely xantophyll, lutein, and zeasantin as well as a small amount of beta-carotene and cryptoxanthin. The color or pigment contained in the yolk is greatly influenced by the type of pigment contained in the ration consumed (Winarno, 2002). The more CGM content in the feed given, the color of the yolk will be closer to orange. This is because CGM (Corn Gluten Meal) consists of gluten obtained when the starch is separated and has a very yellow color because it contains xanthophylll levels that are high enough for egg yolk coloring (Umiyasih and Vienna, 2008). Therefore, the yolk in the P3 treatment group (CGM 15%) showed a large number when tested with egg yolk colour fan.

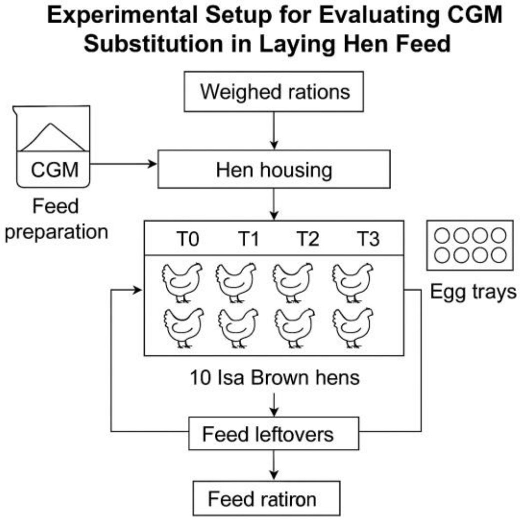

Fig. 5: Experimental Setup for Evaluating CGM Substitution in Laying Hen Feed

Illustration of the experimental setup used in the study. The schematic shows the layout of the hen housing divided into 4 treatment groups (T0–T3), each containing 10 Isa Brown hens. The feeding system included individually weighed rations with varied levels of CGM substitution. Feed was distributed daily, and feed leftovers were collected and weighed every 24 hours. Egg trays were labeled per group to record egg number, weight, and yolk color. Feed preparation included mixing CGM with basal rations to ensure homogeneity before distribution.

3.1 Practical Challenges in the Use of CGM in Laying Hen Diets

While the substitution of Corn Gluten Meal (CGM) in laying hen diets shows promising results in improving feed conversion efficiency, enhancing yolk pigmentation, and maintaining egg production, several practical challenges must be carefully considered to ensure the feasibility and sustainability of its application in the field.

3.2 The availability and supply chain of CGM

The availability and supply chain of CGM can pose limitations, especially in regions where CGM is not produced locally or where corn wet milling industries are scarce. CGM is a by-product that relies on industrial corn starch extraction, which may be concentrated in certain geographic locations. This could lead to inconsistent supply, seasonal fluctuations, and logistical constraints in procurement, particularly for small- and medium-scale poultry farmers who do not have access to large feed manufacturers or importers.

3.3 The cost of CGM is another critical factor

Although CGM is often used as an alternative protein source, its price can vary significantly depending on global corn prices, energy costs for processing, and international trade dynamics. In some markets, the cost per unit of digestible protein from CGM may actually exceed that of more traditional sources like soybean meal, thus limiting its economic advantage. For large-scale application, a cost-benefit analysis should be conducted to ensure that improvements in feed conversion and yolk color are not outweighed by increased feed formulation expenses.

3.4 Nutritional imbalances may occur at higher levels of CGM substitution

CGM is known for its high protein content and xanthophyll concentration; however, it also contains low levels of essential amino acids such as lysine, which is crucial for optimal egg production and overall health of laying hens. If CGM is used excessively without appropriate balancing of the amino acid profile—either through supplementation or strategic blending with other ingredients—it can lead to subclinical deficiencies, impaired productivity, or even metabolic stress.

Furthermore, the variability in CGM composition—due to differences in corn source, processing methods, and moisture content—can result in inconsistent performance outcomes if not properly monitored. Nutrient composition tables may not always reflect the actual values of the CGM batch being used, highlighting the need for routine nutritional quality control in feed formulation.

In conclusion, while CGM offers functional and nutritional benefits in laying hen feed, its practical implementation requires careful attention to supply stability, cost-effectiveness, and formulation precision. Future research should explore optimal inclusion levels under different economic conditions and assess strategies for balancing nutrient profiles when CGM is used extensively, thereby ensuring that its application remains both biologically effective and economically viable in commercial poultry production systems.

4. Conclusion

The substitution of corn gluten meal (CGM) in feed has no effect on the number of eggs produced by Isa Brown laying hens. However, a significant effect was seen on egg weight, where the treatment group that was given CGM as much as 10% of the feed composition showed the largest average egg weight. In addition, CGM substitution also influenced feed conversion, with the smallest average feed conversion found in the treatment group given CGM as much as 15% of the feed composition. Another influence was seen in the color of the yolk, where the group of chickens that received a CGM of 15% in the feed had the color of the yolk with the highest score of 13 and an average of 12.33. This suggests that the use of CGM in feed can affect several parameters of laying hen production, especially in terms of egg weight, feed efficiency, and yolk color.

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