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Physical Characteristics of Eggs from Layer Chicken Fed with Marigold (*Tagetes erecta*)

Angel Grace Veñegas[1], Judie Alingas[1], Reynald Suresca[1], Armigenia O. Benedicto[1], and Armando Abaño[1]

[1] College of Arts and Sciences, University of Negros Occidental-Recoletos, Incorporated, Bacolod City, Philippines

ABSTRACT

The marigold flower, scientifically known as Tagetes erecta, contains carotenoids. A carotenoid is a group of pigments in vegetables, fruits, and flowers. It is widely used in cosmetic, pharmaceutical, and food industries, which are identified to decrease egg cholesterol and increase yolk color. This experimental study evaluated the effectiveness of dried marigolds as a feed additive in enhancing the physical characteristics of chicken eggs, such as yolk color, weight, and size. Likewise, hen day egg data was also gathered to know its relationship with the different physical characteristics of an egg. Furthermore, this study aimed to determine the economic benefit of improving the physical characteristics of eggs of layer chicken fed with marigolds as a feed additive. Forty-eight culled layer chickens were used in a Randomized Complete Block Design with the following dietary treatments: five, ten, and 15 percent with four replications. Adding dried marigold petals mixed with pure commercial feeds affected the physical characteristics of eggs, such as their yolk color, size, and weight, which revealed highly significant results. Eggs of layer chickens fed with 15% dried marigold petals achieved the best yield in yolk color with the darkest shade of yellow-orange pigment, corresponding to a color value of 12.31. Furthermore, layer chickens fed with ten percent dried marigolds gained the heaviest egg weight with a mass of 69.04 grams, considered an "extra-large" size. Applying different percentages of dried marigold petals as a feed additive in the poultry diet effectively improved the physical characteristics of eggs, such as egg yolk color, egg weight, and egg size.

Keywords

carotenoids, feed additive, marigold, physical characteristics, poultry diet

INTRODUCTION

Layer chicken is a domestic fowl scientifically known as *Gallus gallus domesticus*, usually raised for egg production. An egg is a good source of protein, vitamins, and minerals. The more significant part of the protein of an egg is usually found in the egg white. While lipids, vitamins, and minerals are present

in egg yolk. Egg nutrients can be affected by many factors, including hen nutrition (Réhault et al., 2019).

Furthermore, egg protein is about 6.5 g/egg, which contains a balanced supply of nine amino acids essential to human health. These amino acids are vital in producing enzymes, some hormones, DNA components, and other components essential for growth and tissue maintenance. Indeed, an egg has many excellent benefits for our body (Zaheer, 2015).

In recent years, egg production has been an issue worldwide regarding animal welfare. However, egg production has increased worldwide because it is in high demand, inexpensive, and easy to cook.

In 2019, the Philippine Statistics Authority reported that the total volume of chicken egg production from April to June 2019 was 141,450 MT, 7.9 percent higher than the previous year's level of 131,100 MT. CALABARZON became the top producer of eggs at 41,400 MT. This number accounted for 29.3 percent of the total egg production in the country. Meanwhile, Central Luzon and Northern Mindanao regions ranked second and third, having shares of 20.4 percent and 9.3 percent, respectively. The average farm-gate price of chicken eggs in commercial farms from April to June 2019 was recorded at Php 4.65 per piece. This data was 7.2 percent higher than the average cost of P4.34 per piece in 2018.

According to Espina from an article on the Visayan Daily Star (2020), chicken egg production in Western Visayas increased by 11 percent in 2018. Negros Occidental remained the top producer of chicken eggs, with 13,222 MT in 2018 from 12,552 MT in 2017, yielding an increase of 5.33 percent. Next to Negros Occidental is Iloilo with 11,766 MT, Capiz with 4,374 MT, Antique with 2,189 MT, Aklan with 1,615 MT, and Guimaras with 1,185 MT.

It is the strong support of the provincial government of Negros Occidental that made the province the top producer of eggs in the region. The Provincial Veterinary Office (PVO) provided a poultry layer project to 30 farmers' associations in Negros Occidental. The 30 farmers' associations produced 264,000 fresh eggs in five months from April to August in 2018. This production aimed to ensure food security and reduce poverty in the province. Under this program, 3,000 heads of ready-to-lay pullets and 30 units of layer cages were distributed by the area to various farmer associations. According to a press statement of PVO in SunStar Bacolod (2020), the project is an alternative source of daily income for farmer-beneficiaries. It is a countermeasure to the increasing market price of the commodity.

However, feed consumption, water intake, diseases, and lack of nutrients may affect egg production. Furthermore, there are still other factors that affect egg production. According to a study by Folorunso et al. (2013), layer chicken placed in a battery cage should have a good water source, and strict farm hygiene must be observed since unclean water will have a high bacterial load. Another study by Englmaierová et al. (2018) stated that the housing system influenced eggs' internal and external characteristics. Further research by Morris (2004) revealed that a chicken diet containing excess protein can lead to impaired utilization of amino acids; this is supported by Johnson (2020), who reported that vitamin D is significant for calcium absorption because, without it, calcium sources are depleted. The study further stipulated that three to four percent of calcium is vital for eggshell formation. In addition, egg producers must ensure high calcium levels in a diet two weeks before laying should start. Failure to provide a high calcium level may affect egg production (User, 2010).

Aside from all the nutrients people can acquire from an egg, the color of the egg yolk also plays a vital role in consumers' preference in choosing an egg (Beardsworth & Hernandez, 2020). The egg yolk provides nutrients such as protein, lipids, vitamins, and minerals (Huopalahti, 2007). However, there has been an issue concerning the high cholesterol

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content of the egg yolk. People only eat the egg white and discard the yolk. Meanwhile, some people believe that yolk can increase the risk of heart disease. Regardless, our body needs cholesterol to produce more testosterone, which helps increase energy levels and build muscles (Spritzler, 2016).

Though egg yolk color is one of consumers' preferences when choosing eggs, a study in Bangladesh revealed that poultry farms in many countries could not obtain a desirable degree of egg yolk color. The same study used marigold and orange skin as color enhancers for egg yolks. The results showed that using marigold as a color enhancer was more efficient than using orange peels (Hasin et al., 2006).

Other countries used the marigold flower as a natural pigmentation for egg yolk. Many studies utilize the marigold flower in veterinary feeds. However, the utilization of marigold as a natural colorant was not used to its full potential mainly because of the need for more data on its safety, stability, and similarity in food sources. Nonetheless, the marigold flower is still used as a natural pigment and many studies prove that marigold contains a much beneficial compound like carotenoids.

Marigold is an edible flower described as innocuous and nontoxic with health benefits when consumed as part of a human diet. The phytochemical composition of the marigold flower has useful properties containing many therapeutic values if they are correctly processed. Furthermore, drying marigold flowers was the most effective method of conserving them. However, those processing technologies concerning drying are still to be studied (Chitrakar et al., 2019).

According to a study by Sowbhagya et al. (2004), carotenoids are plant pigments responsible for the different hues in many fruits, vegetables, and flowers. This color pigment has obtained noteworthy importance considering its cell-reinforcement properties. Some carotenoids ingested by our body are converted into vitamin A, essential for growth, immune system function, and eye health.

Marigold flower extract is a natural source of carotenoid and is used as a feed additive in poultry diets. Carotenoids are believed to be chemo-preventive agents because their antioxidants have been shown to decrease egg cholesterol and increase egg yolk color (Nuraini et al., 2016). Animals, including humans, cannot synthesize carotenoids. The most ingested carotenoid can be obtained from our natural diet, especially vegetables and fruits (Britton et al., 2009).

In the study of Wang et al. (2017), the marigold extract is a xanthophyll pigment mixture extracted from marigold flowers. Lutein and a few zeaxanthins are their active ingredients which are safe as they are naturally present in edible plants. Xanthophyll is a carotenoid that protects humans from too much sunlight. It is most associated with eye health. Lutein and zeaxanthin are the only dietary carotenoids that accumulate in the retina, particularly the macula region at the back of the eye.

Among the natural pigments, marigold meals and extracts are the most widely accepted products in poultry feed. However, most previous studies on dietary marigold extract in poultry have mainly concentrated on poultry pigmentation and their products, especially egg yolk pigmentation. A further study by Saling et al. (2006) said that carotenoid pigments are used as feed additives in the poultry sector and salmonid and crustacean aquaculture. In these applications, the target species' egg, skin, or flesh was pigmented with carotenoid pigments to improve marketability.

A further study reported that marigold petal meal and its residue are good sources of xanthophyll, used in layer diets as an egg-yolk-pigmenting agent (Sujatha et al., 2015a). Relative to this, xanthophyll can be found in marigold flowers, but only a few use

it as a feed additive in poultry farming (Breithaupt, 2007).

In the Philippines, marigolds are used as insect and pest repellents. They help control the pest population and are also considered medicinal plants. However, marigolds' efficacy has yet to be proven.

In Negros Occidental, people say that some poultry farms use egg-yolk-color-promoting agents that contain marigolds. However, the use of marigolds as a natural pigment of egg yolk in the province has yet to be fully utilized and developed. Some poultry raisers are unaware of the benefits of marigold as a color enhancer of egg yolk.

Based on this premise, the researchers conducted this study to evaluate the effectiveness of dried marigold petals mixed with pure commercial feeds as the diet of layer chickens to improve the physical characteristics of their eggs, such as yolk color, size, and weight. The use of marigold as a yolk color enhancer has yet to be widespread in the poultry farming business. Likewise, this study further aimed to provide data to small poultry growers in enhancing the physical characteristics of eggs they produce at a lesser cost. Furthermore, a diet rich in carotenoids present in the egg will help many people with concerns about their eye health and growth problems (Jothi, 2008).

METHODOLOGY

The study sought to evaluate the effectiveness of different percentages of dried marigold petals as a feed additive to improve the physical characteristics of eggs, such as yolk color, weight, and size. Forty-eight culled layer chickens were divided randomly into four treatments with four replications using Randomized Complete Block Design (RCBD). The data gathered in this study were statistically analyzed using Analysis of Variance (ANOVA). The following treatments were: five percent, ten percent, and 15 percent substitution of dried marigold petals added to pure commercial feeds. This study was conducted at the School of Agriculture, University of Negros Occidental–Recoletos, from December 3 to February 11, 2019. Before conducting the study, marigold plants were already grown in advance in Agriculture. The researchers sourced out culled layer chickens placed in the battery cage at the School of Agriculture area. Based on the ethical handling of the chickens, the researchers ensured that the culled layer chickens were placed in an adequate and happy environment so that they would produce better quality products, in this case, their eggs (Macer, 2018).

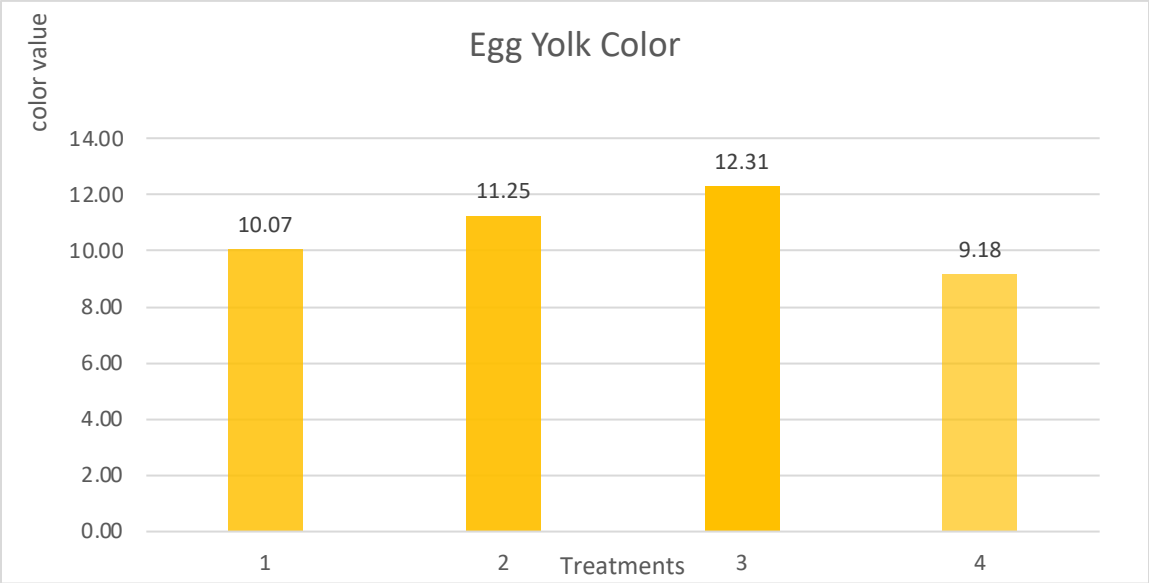
When in full bloom, marigold flowers were harvested, usually in the afternoon. The marigold petal was cut below the sepal using scissors, then separated the seeds. The petals were spread in the net and air-dried at a room temperature of 32 degrees Celsius. The air-dried petals were checked twice daily and jumbled to avoid mold growth. The collected air-dried petals with ten percent moisture content were placed in clear zip-lock plastic bags to prevent contamination.

All materials and tools used to prepare feeds and marigold additives were cleaned and sanitized to avoid contamination.

Before the actual feeding of layer chickens, both air-dried marigold petals and pure commercial feeds were subjected to laboratory analysis to determine the crude protein content, crude fat, crude fiber, and carbohydrate in collaboration with the Provincial Feed and Meat Laboratory, Provincial Veterinary Office, Negros Occidental. The dried marigold petals and commercial feeds were weighed following the recommended application per treatment using a digital kitchen scale. The petals were pounded using a mortar and pestle into a slightly fine texture and mixed well with the feeds in a clean pail.

Forty-eight culled layer chickens were divided randomly into four treatments with four

Figure 1
Egg Yolk Color



replications. Four treatments tested in the study following the recommended application were: 5% of dried marigold petals mixed with 95% pure commercial feeds, 10% of dried marigold petals mixed with 90% pure commercial feeds, and 15% of dried marigold petals mixed with 85% pure commercial feeds. One hundred percent pure commercial feeds were used as the Control. The gathering of egg samples was done per treatment in all four replications. Data was gathered twice daily, from 8:00 am to 4:00 pm, for seven consecutive days.

Yolk color was determined using the DSM Yolk Color Fan with 16 colors (Grashorn, 2016). Blades of the DSM Yolk Color Fan were immediately compared with the egg yolk, with the comparison being viewed vertically from above, the blade numbers facing down, and the yolk positioned between the blade's tips. A researcher faced the side of the edge without numbers and read a name to another researcher for recording. The fan was closed after each reading to ensure the independence of every measurement. Egg size was classified based on the standard table for egg size. Each egg sample was weighed using a digital kitchen-type weighing scale. Hen day egg production was also included as additional study data to assess the relationship with different physical characteristics of eggs.

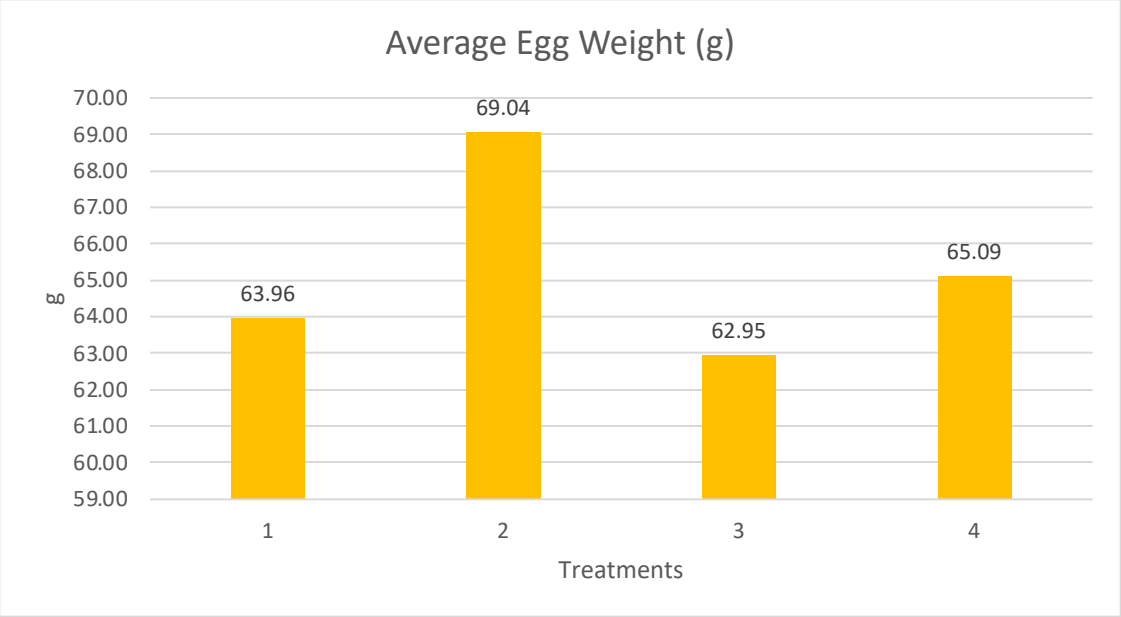
This study was limited to the physical characteristics of eggs from layer chickens fed commercial feeds mixed with different percentages of dried marigolds. Given that the physical aspects of an egg from a layer chicken can be identified through various methods and variables, this study is limited to yolk color, weight, size, and hen-day egg production.

RESULTS, DISCUSSION, AND IMPLICATIONS

The study's results showed a significant difference in the effects of different percentages of dried marigold petals on the physical characteristics of eggs from layer chickens, such as yolk color, egg weight, and egg size, based on the recommended application per treatment.

The densities of egg yolk color fed with dried

Figure 2
Average Egg Weight



marigold as a diet for layer chickens were significantly different from each application per treatment. The result showed that layer chicken fed with 15% dried marigold and 85% commercial feeds (Treatment 3 or T3) obtained the darkest shade of yellow pigment with a color value of 12.31 which was significantly different from Treatment 2 (T2) (10 % dried marigold, 90 % commercial feeds) with a color value of 11.25, showing a significant difference of 1.06. Layer chicken fed with Treatment 1 (T1) (5% of dried marigold, 95% commercial feeds) had a significantly different color value of 10.07, notably different from the egg yolk color fed with T2 and T3. Furthermore, layer chickens fed with pure commercial feeds (Treatment 4 or Control) had the lowest color value of 9.13 and showed pale egg yolk color.

This result showed that the addition of 15% marigold in the feedlot obtained the darkest egg yolk colors, which signified that the darker the egg yolk color, the more carotenoids the egg yolk contains; this was supported by the study of Nuraini et al. (2016), which revealed that carotenoids, as chemo-preventive agents due to their antioxidant properties, were shown to decrease egg cholesterol and increase egg yolk color. According to a study by Siriamornpun et al. (2012), carotenoid content is affected by different drying methods. Major carotenoids found in marigolds were lutein, lycopene, and β-carotene. Hot air-drying gave the highest content of β-carotene. Moreover, Lokaewmanee et al. (2011) reported that dietary lutein present from marigold enhances egg yolk color at approximately 30 to 40 mg. Consumers prefer dark egg yolk color, which corresponds to the value of 12 or more based on DSM Yolk color according to DSM's current Egg Yolk Pigmentation Guidelines (Grashorn, 2016).

Relatively, a study by Li (2016) stipulated that Australian egg producers have added color enhancers such as marigold, paprika, and capsicum to chicken feed pellets to improve egg yolk color. According to the study, the color of the yolk depends on the chicken's diet. If the yolk cannot become naturally

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yellow, egg producers add a color dye to enhance its color.

As to the egg weight, the result showed that eggs of layer chickens fed with T2 (10% of dried marigold, 90% commercial feeds) obtained the most substantial egg weight with a value of 69.04g, classified as "extra-large" egg size based on the Standard Table for Egg Size. The result from T2 was significantly different by 3.95 from T4 (100% commercial feeds) which only obtained a weight value of 65.09 g. Whereas layer chicken fed with T1 (5% dried marigold, 95 % commercial feeds) had a significantly different egg weight value of 63.96 g, lower than the egg weight values in T2 and T4. Furthermore, the layer chickens fed with T3 (15% marigold, 85% commercial feed) showed the lowest egg weight value of 62.95g.

According to a study by Şekeroğlu and Altuntaş (2008), the darker the egg yolk, the more massive the weight of an egg. Based on a study by Sujatha (2015b) the production of pigment-enriched eggs from Desi chickens fed with Tagetes erecta petals was inferior compared to layer chickens involving marigold-petals-mixed feeds based on its higher egg production, heavier egg weight, larger egg mass, and better feed efficiency and yolk percent.

Egg size (g) by weight of layer chicken fed with dried marigold petals was measured based on the result of egg weight. Eggs from layer chicken fed with T2 (10% dried marigold petals mixed with pure commercial feeds) obtained the largest egg size with a value of 69.04g, considered "extra-large" based on recommended egg sizing. Whereas layer chicken fed with T1 (5% dried marigold petals) with a weight value of 63.96g, T3 (15 % of dried marigold petals) with a weight value of 62.95g, and T4 (100% Pure commercial feed) with a weight value of 65.09 obtained the same result for size which was categorized as "large".

According to another study by Altunas and Sekeroglu (2010), egg size is determined by weight, including small, medium, large, extra-large, and jumbo. According to the study by Abiola et al. (2018), the age and body weight of a hen, yolk weight, and

Figure 3
Egg Size By Weight

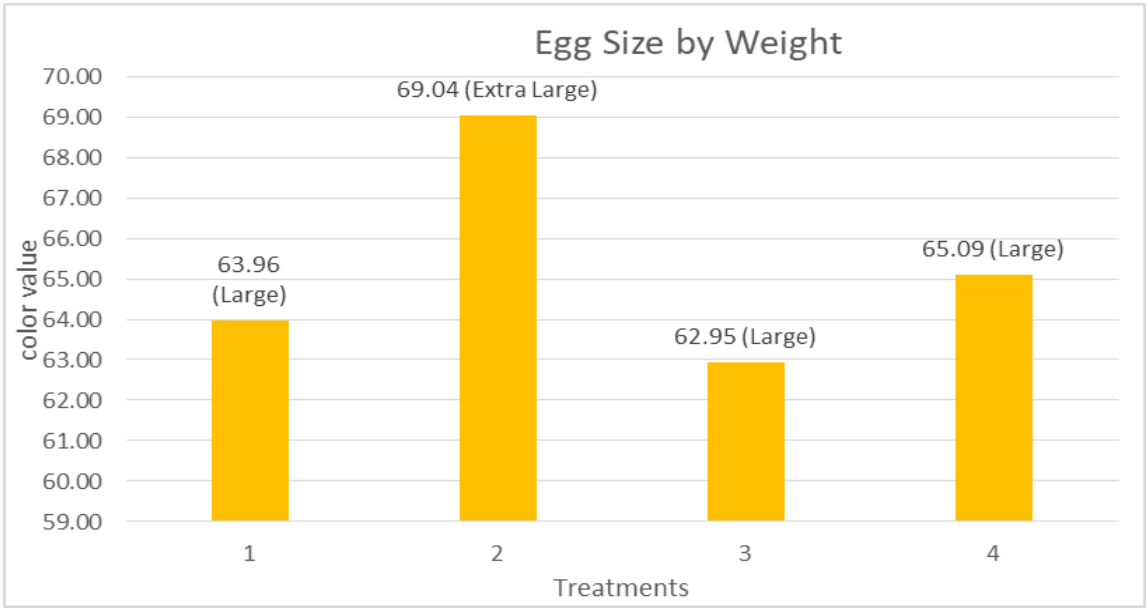


Table 1
EAA's Farm recommended Eff Sizing Range

Range	Size
52-57 grams	Small
58-62 grams	Medium
63-67 grams	Large
68-72 grams	Extra-Large
72 grams and up	Jumbo

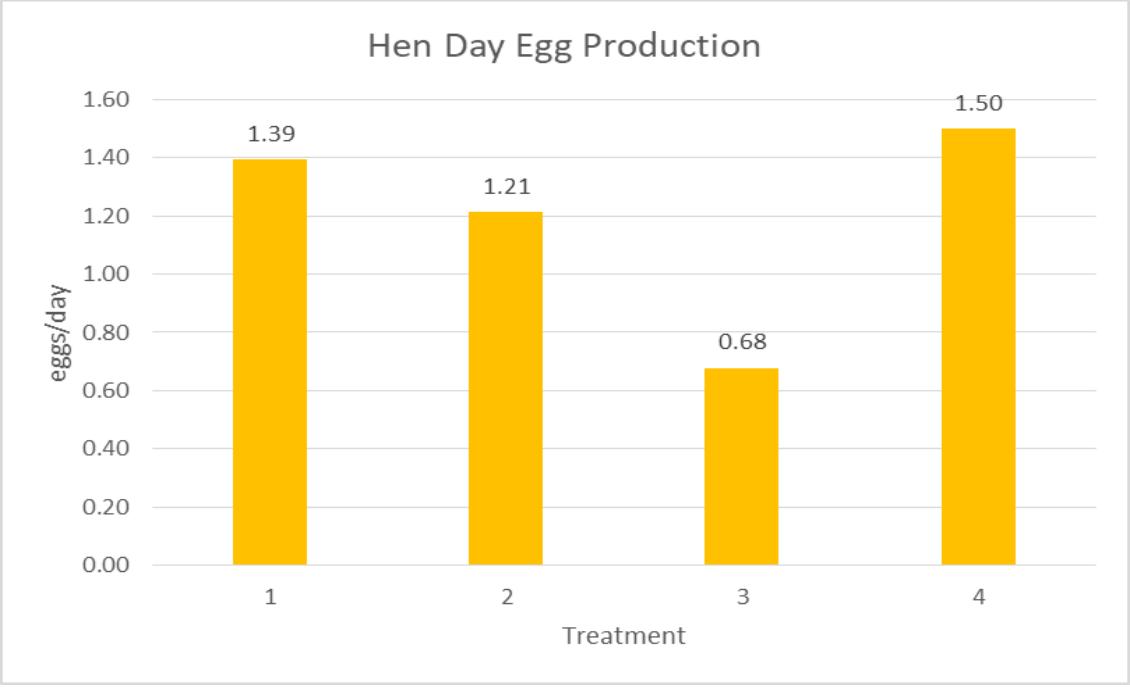
nutrient intake can influence egg size. According to Akinbobola (2020), egg size can be affected by the hen's age. Eggs usually produced by cull layer chickens can reach up to 70g.

The United States Department of Agriculture stated that the most significant variables in egg size are the chicken's age and weight. Generally, the older and larger the hen, the larger the eggs. However, egg size can also vary according to diets and living conditions.

Additional data on hen day egg production of layer chicken were also gathered per day. The result showed that layer chicken fed with pure commercial feeds (T4) obtained the highest number of eggs per day per chicken, with a value of 1.50 eggs/day. This result significantly differed from T1, T2, and T3, wherein the latter obtained the lowest value of egg production per day. Egg production, as expected, was also lower due to the age of layer chicken (Usman & Diarra, 2008).

Based on the overall results, T3 is highly recommended for its yolk color, with a density of 12.31. However, the hen day egg production in T3

Figure 4
Hen Day Egg Production



was low compared to the other treatments. This result is due to the high fiber content of the marigold. According to a study on high-fiber diets, a diet with high crude fiber swells the stomach, resulting in a hen's low feed intake because it activates the center of satiety (Praes et al., 2014). On the other hand, T4 had the highest number of eggs for hen-day egg production. However, it had only a 9.18 yolk color density compared to the other treatments mixed with marigold petals.

CONCLUSION AND RECOMMENDATIONS

Evaluating the effectiveness of dried marigold petals as a feed additive to the diet of layer chicken resulted in a positive effect. This study proved that adding dried marigold petals in commercial poultry feeds improved egg yolk color, weight, and size.

Based on the study's results, the following conclusions were formulated: The addition of varying percentages of dried marigold as a feed additive effectively improved the physical characteristics of eggs, such as yolk color, weight, size, and hen-day egg production.

The study's return on investment showed that it is economically feasible to use marigolds as a feed additive to enhance the physical characteristics of layer chicken eggs.

This study sought to contribute to the improvement of poultry farming not just in Negros Occidental but also in the Philippines. With this study, poultry farmers will have other options to improve the physical characteristics of layer chicken eggs and to disseminate information to other poultry raisers that marigold petals can be used as a natural additive to commercial layer feed to boost the physical characteristics of eggs of layer chickens. Furthermore, this study could help marginal farmers with less financial capability reduce their expenses in poultry growing since marigolds are easy to grow and cost little. Marigold also serves as both pest repellant and attractant of good and beneficial insects such as butterflies. One of the essential properties found in marigolds is carotenoids, which have significant effects in aiding different health problems aside from being an additive to commercial feeds. This study is also significant in improving the nutritional status of the consumer population, especially children, once they consume eggs with improved physical characteristics and nutritional content.

On the other hand, the results gathered for T1, T2, and T3 implied that these can be recommended to poultry raisers who aim for excellent egg physical characteristics. All these treatments produced good color yolk density. A study conducted by Hasin et al. (2006) revealed that consumers worldwide prefer to buy eggs with a yolk of high color density, usually ranging from golden yellow to orange. The high hen day egg production results in T1 and T4 were noted.

Researchers recommended the following future studies, in which marigold petals may be used as feed additives to increase the nutritional value of eggs of layer chickens, feed additives to lower the cholesterol levels of eggs of layer chickens, and feed additives to improve the eggshell quality of eggs of layer chickens.

These are based on a study conducted by Ahmadi and Rahimi (2020), which reported that eggshell quality is influenced by the strain and age of the hen, induced molt, nutritional factors such as calcium and vitamins, contamination of feeds, diseases, and the addition of products to the diet.

Since the use of marigold as a yolk color enhancer is not yet widespread in the poultry farming business, the researchers highly encourage future researchers to use this study to prove further theories on the use of marigold or other natural yolk-color-enhancing agents in ethical experiments on poultry.

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