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Research article

Yellow chili bell pepper (*Capsicum baccatum*) on productive and pigment parameters in broiler chickens in the Peruvian highlands

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Abstract

The present study aimed to determine the effect of yellow chili pepper (*Capsicum baccatum*) as a natural pigment in the diet of broiler chickens. The study was conducted at the Yauris Experimental Station of the Universidad Nacional del Centro del Perú. A total of 120 animals were used, distributed across four treatments with the inclusion of yellow chili pepper flour (T0 = 0%, T1 = 10%, T2 = 15%, and T3 = 20%). The initial weights of the chickens were homogeneous across all groups. However, significant statistical differences were observed in weight gain ($P<0.05$), with the T3 group achieving the highest weight gain of 2,493.3 g. Similarly, for final weight, the T3 group showed superior results with 2,604.1 g, and for carcass weight, T3 was outstanding with 2,484.2 g. The amount of β-carotene in the leg region was highest in the T3 group at 0.0716 mg/100g, and in the breast region, T3 also showed the highest amount with 0.046 mg/100g. In conclusion, the inclusion of yellow chili pepper flour in the diet of broiler chickens not only increases weight gain and carcass yield but also enhances the β-carotene content in the meat, serving as an effective natural pigment.

Keywords: Broiler chickens, Broiler carcass, Meat pigmentation, Natural feed, Production performance.

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INTRODUCTION

The global poultry industry has experienced sustained growth in recent decades (Castro et al., 2023; Korver, 2023), driven by the increasing demand for chicken meat, an accessible and nutritious source of animal protein (Goluch et al., 2023; Hossain et al., 2023). In this context, the pigmentation of broiler chicken carcasses has become a fundamental quality attribute (Ashour et al., 2021; Grigore et al., 2023), directly influencing consumer preference and the market value of the product (Altmann et al., 2023; Kudumija et al., 2024). Traditionally, synthetic pigments have been achieved by adding pigments to chicken diets (Chavez et al., 2022). However, interest in natural alternatives has increased due to concerns about food safety and environmental sustainability (Benucci et al., 2022). Yellow chili pepper (*Capsicum baccatum*) is a species of pepper native to South America, widely cultivated in Peru; recognized for its high carotenoid content, especially β-carotene and lutein, which are responsible for its intense yellow coloration (Carillo et al., 2022). Carotenoids, in addition to their ability to act as natural pigments (Maoka, 2020), possess antioxidant properties that can contribute to animal health and well-being (Krinsky, 1988; Young and Lowe, 2018). Incorporating yellow chili pepper into broiler chicken feed could improve carcass pigmentation naturally and potentially enhance the final product's nutritional quality (Giuffrida et al., 2013; Sözcü, 2019).

The agroclimatic conditions of the highlands of Peru are ideal for cultivating yellow chili pepper, facilitating its availability and reducing production costs (Aguirre-Sosa et al., 2023). Nevertheless, implementing this ingredient in broiler chicken diets requires a detailed analysis to evaluate its effects on carcass pigmentation, the use in the Andean areas of Peru, will allow to take advantage of the cost and above all to use natural producers in pigmentation. Therefore, this study aimed to investigate the use of yellow chili pepper (*Capsicum baccatum*) as a natural pigment in broiler chicken feed in the highlands of Peru.

MATERIALS AND METHODS

The procedures and ethics of animal use, specifically concerning chicken. This is authorized by letter No. 008-GRJ-DRA-AAC-PERÚ-2023, issued on december 22, 2023, by the "Dirección Regional de Agricultura". Furthermore, the study was conducted following international and national guidelines for the care and use of animals in research.

Study Area

The study was conducted at the Yauris Experimental Station of the National University of Central Peru, located in the Huancayo, Junín region, Peru. The station is 3204 meters above sea level and receives 750 mm of rainfall annually (Senamhi, 2023).

Animals and distribution

The study lasted 7 weeks, and used a total of 120 broilers Cobb 500, 2 days old, distributed across four treatment groups with varying levels of yellow chili pepper meal: T0 = 0%, T1 = 10%, T2 = 15%, and T3 = 20%. (Figure 1d). Each treatment group comprised 30 animals, with an equal number of males and females (15 each). The evaluation period lasted for seven weeks, starting with an initial average weight of 45 grams, which showed no significant differences among groups ($P>0.05$). Chickens were administered antibiotics (Sulfa K) three times throughout the study (1, 15 and 25 days) to prevent possible infectious diseases. Additionally, all animals were housed in light-controlled environments maintained at a temperature of 30°C. Feed and water were supplied ad libitum, and their consumption was monitored daily. The feed containing the yellow chili bell pepper meal consisted of a mixture of several ingredients, as detailed in Table 1.

Table 1 Nutritional values of feedstuffs in broiler chicken feed

Product Composition	Season			
	T0	T1	T2	T3
Percentage of inclusion (%)				
Yellow chili pepper	0	10	15	20
Food feed	100	90	85	80
Nutritional Value (%)				
Yellow corn	60.00	54.00	51.00	48.00
Wheat sub product	15.00	13.50	12.75	12.00
Rice sub product	10.00	9.00	8.50	8.00
Soybean paste	10.00	9.00	8.50	8.00
Palm oil	0.30	2.70	2.55	2.40
Minerals	0.20	1.80	1.70	1.60
Nutritional value (%)				
Protein crude PC	22	23.72	24.58	25.44
Grasa crude GC	6	6.43	6.65	6.86
Fibra crude FC	4	4.29	4.44	4.58
Humedad H	13	13.6	13.9	14.2
Ceniza Cz	10	11	11.5	12

Composition nutrional aji Amarillo (CP:17.2%, GC:4.3%, FC: 2.9%, H: 6.0%, Cz:10%) Mineral: Fosfato monosodico, Carbonato de Calcio, Sulfato de lisina, DL Metionina, DL Treonina, L Triptófano, Vitamina A, Vitamin D3, Vitamina K

Preparation of yellow chili pepper flour

The yellow bell pepper was purchased in the wholesale market, from a single supplier. (Figure 1a). It was then selected and separated from seeds and veins, and subsequently cut into strips to be dried at 40°C for 8 hours using a laboratory dryer (ESTUFA BONALS Model 75III/I) (Figure 1b). The dried strips were ground using a milling machine model 6F2235 to obtain the flour (Figure 1c). The yellow chili pepper was sourced from the coast. A total of 250 kg of dehydrated raw material was used as a pigmenting ingredient during the finishing stage of broiler chicken production.

Data collection

Productive performance

For slaughter, a restraint cone was used to immobilize the bird immediately. For the evaluation of weights (initial weight, final weight, and carcass weight), a Patrick's AM3 scale was used, the scale used for weighing had a margin of error of ±0.01 g, ensuring accurate measurements. Weight assessment was carried out following the guidelines of Carhuas et al. (2023), which detail accurate methods for assessing poultry weights. The determination of beta carotenoids was performed using a SHIMADZU high-performance liquid chromatography (HPLC) system with a diode array detector. The meat location for the evaluation was from the leg and breast, 4 kg cuts of meat pulp were made. The analyses were conducted using a C18 column with 5 µm particle size, 150 mm length, and 4.6 mm internal diameter. The mobile phase consisted of 20% methanol, 73% acetonitrile, and 7% ethyl acetate. Elution was carried out with a flow rate of 1.5 mL/min under isocratic conditions. The carotenoids were monitored using a UV-VIS detector at 450 nm. Twenty microliters of each extract were injected into the separation column for carotenoids at a temperature of 25°C, with an analysis time of 30 minutes for each sample. The quantification of carotenoids was based on calibration curves corresponding to β-carotene standards.

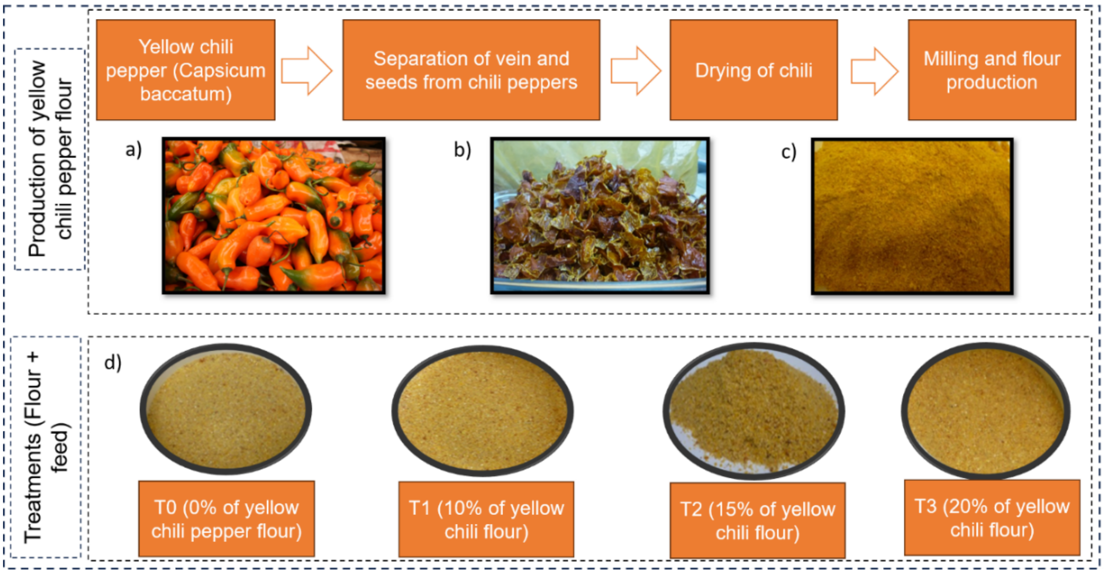

Figure 1 Methodology for obtaining yellow chili flour and distribution of treatments

Statistical Analysis

Differences between treatments were determined by analysis of variance (ANOVA), followed by a multiple comparisons test. A value of $P<0.05$ was considered different, all statistical analyses were performed with CRAN R software (R Team Core, 2019), and version 4.3.0 (Kassambara and Mundt, 2017) was used.

RESULTS

Productive performance

The results obtained, detailed in Table 2, show variations in the productive performance of the chickens throughout the study period. The initial weights of the chickens were homogeneous across the different experimental groups, with values of 110.7 ± 2.3 g for T0, 111.1 ± 2.3 g for T1, 111.2 ± 2.1 g for T2, and 110.9 ± 1.7 g for T3. No significant differences ($P > 0.05$) were found in the initial weights, indicating an equitable distribution of weights at the beginning of the experiment.

Weight gain is a crucial indicator of productive performance in poultry farming. During the experimental period, chickens fed higher levels of yellow chili pepper flour showed a significant trend toward increased weight gain. The values were 2096.8 ± 105.4 g in T0, 2177.5 ± 79.5 g in T1, 2350.2 ± 83.8 g in T2, and 2493.3 ± 18.2 g in T3. Treatments T2 and T3 exhibited significantly greater weight gain compared to T0 and T1 ($P < 0.05$), suggesting that higher levels of yellow chili pepper flour improve feed conversion efficiency and growth in chickens.

The final weight of the chickens also showed an increase correlated with the inclusion of yellow chili pepper flour in the diet. The recorded final weights were 2207.5 ± 105.4 g for T0, 2288.5 ± 79.8 g for T1, 2461.4 ± 85.2 g for T2, and 2604.1 ± 18.5 g for T3. The differences observed between T0 and T1 compared to T2 and T3 were statistically significant ($P < 0.05$). The results indicated that carcass weight increased with the inclusion of yellow chili pepper flour. The weights were 2018.1

± 107.1 g in T0, 2115.5 ± 82.9 g in T1, 2298.9 ± 87.8 g in T2, and 2484.2 ± 18.5 g in T3. Treatments with higher percentages of yellow chili pepper flour (T2 and T3) had significantly higher carcass weights compared to T0 and T1 ($P < 0.05$). Regarding the amount of β-carotene in the leg (Figure 2), there were statistically significant differences ($P < 0.05$) among all treatments: T3, T2, T1, and T0 with 0.0716, 0.0366, 0.0139, and 0.0041 mg/100g, respectively. Similarly, for β-carotene in the breast of broiler chickens, significant differences ($P < 0.05$) were found among treatments T0, T1, T2, and T3 with 0.004, 0.013, 0.0277, and 0.046 mg/100g, respectively

Table 2 Results for treatments with the addition of yellow chili pepper flour

Performance	T0	T1	T2	T3
Productive performance				
Initial weight (gr)	110.7^{a} ± 2.3	111.1^{a} ± 2.3	111.2^{a} ± 2.1	110.9^{a} ± 1.7
Weight gain (gr)	2096.8^{a} ± 105.4	2177.5^{b} ± 79.5	2350.2^{c} ± 83.8	2493.3^{d} ± 18.2
Final weight (gr)	2207.5^{a} ± 105.4	2288.5^{b} ± 79.8	2461.4^{c} ± 85.2	2604.1^{d} ± 18.5
Casing weight (gr)	2018.1^{a} ± 107.1	2115.5^{b} ± 82.9	2298.9^{c} ± 87.8	2484.2^{d} ± 18.5

^{a,b} equal letters in the same column do not differ from each other at 95% by *Tukey's post hoc test*.

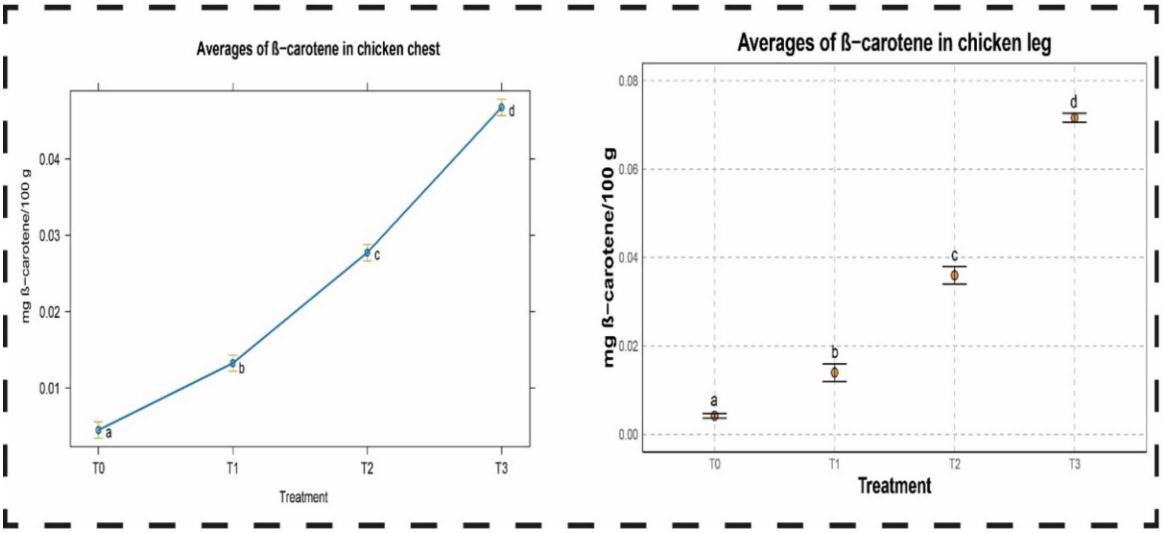

Figure 2 Averages of beta-carotene present in the leg and breast of broiler chickens fed feed containing yellow chili pepper meal

DISCUSSION

Productive performance

The results obtained in this study on the inclusion of yellow chili pepper flour (*Capsicum baccatum*) in the diet of broiler chickens provide compelling evidence of its significant benefits on the productive performance of the birds. The fact that the initial weights of the chickens were homogeneous across the different experimental groups ensures that the observed variations in productive performance are attributable to the applied treatments and not to initial differences among the animals. This initial homogeneity is crucial for the validity of the results, as highlighted in other studies on experimental design in animal nutrition (Dhamodharan et al., 2022).

Weight gain is a crucial indicator of productive performance in poultry farming. Chickens fed higher levels of yellow chili pepper flour (T3) showed a significantly higher weight gain of 2493.6 g compared to the other groups. This finding surpasses the results reported by López et al. (2012), who observed a weight gain of 1794 g in chickens fed with oregano leaf meal. However, it is lower than the weight gains documented by Campozano-Marcillo et al. (2021), who reported an increase of 2815 g with the inclusion of oregano essential oil. Although both studies utilized the same breed of chicken, the discrepancies in weight gain can be attributed to variations in the type of feed used. Nonetheless, there is a consistent similarity regarding the inclusion of pigment-rich feed. These differences can be explained by the different feeds used in the research, consistent with previous studies that have demonstrated that carotenoids in peppers can improve feed conversion efficiency and promote growth (Zimmet et al., 2023). Additionally, bioactive compounds such as capsaicinoids may stimulate metabolism and digestion, thus contributing to greater weight gain. Carotenoids in yellow chili pepper can enhance weight gain in broilers through their antioxidant properties, which reduce oxidative stress and improve feed efficiency (Young and Lowe, 2018; Elashry et al., 2024). Additionally, carotenoids positively affect lipid and protein metabolism, promoting efficient muscle development (Ma et al., 2024). Thus, their inclusion in broiler diets supports improved growth performance and health.

The final weight and carcass weight also increased significantly with the inclusion of yellow chili pepper flour, with the highest average in T3 at 2,620 g for final weight and 2,484 g for carcass weight. These results are superior to those reported by Rugel and Emén (2020), who used *Moringa Oleifera* flour in broiler diets. Still, they are lower than those reported by Delgado and Lizarazo et al. (2021), who reported final and carcass weights of 2904 g and 2202 g, respectively, using the inclusion of *Curcurbita moschata* in chickens. These differences can also be attributed to the feed provided to the animals, the fattening period, and the initial weight. Previous studies have reported that natural pigments can improve meat quality by acting as antioxidants and enhancing the overall health of the birds (Desbruslais and Wealleans, 2022; Sugiharto et al., 2019). The improvement in carcass weight in T3 suggests better conversion of feed into muscle mass, which is beneficial for both producers and consumers, who prefer leaner meat.

Several studies have explored the use of natural pigments in animal feed. For example, Younis et al. (2021) found that the inclusion of red pepper in pig diets improved weight gain and meat quality, results that parallel those obtained in our study with broiler chickens. Additionally, research by Pinatih et al. (2022) on the effects of *Capsicum baccatum* in rats showed improvements in various metabolic parameters, supporting the idea that the bioactive compounds in peppers have beneficial effects across different species (Zimmet et al., 2023).

The significant increase in β-carotene content in the legs and breasts of chickens with the inclusion of yellow chili pepper flour highlights another important benefit. β-Carotene is a potent antioxidant and a precursor of vitamin A (Grune et al., 2010; Miller et al., 2020), essential for growth, vision, and immune health (Anand et al., 2022). Therefore, the enhancement in β-carotene content in the meat not only increases its nutritional value but also can have positive implications for consumer health, promoting a more balanced and nutritious diet. Carotenoids increase β-carotene content in chicken legs and breasts by being absorbed from the diet and deposited directly into muscle tissues, enhancing pigmentation and nutritional quality. The use of natural pigments is important for inclusion in poultry feed, improving consumer purchase preferences and providing an alternative to synthetic pigments.

CONCLUSIONS

The inclusion of yellow chili pepper powder in the diet of broiler chickens not only increases weight gain and carcass yield but also enhances the β-carotene content in the meat. Inclusion of 20% is recommended, to obtain better productive parameters. This increase in β-carotene enhances the nutritional value of the meat.

These findings underscore the viability of using natural ingredients such as yellow chili pepper in animal feed to improve both productivity and the quality of the final product. Additionally, it serves as a natural pigment for use in the poultry industry.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors regarding the publication of this article.

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