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SHORT COMMUNICATION

Effect of *Daucus carota* subsp. *sativus* on pigmentation and profitability of Cobb 500 broiler chicken

Efecto de Daucus carota subsp. sativus sobre la pigmentación y rentabilidad del pollo de engorde Cobb 500

Efeito de Daucus carota subsp. sativus na pigmentação e rentabilidade de frangos de corte Cobb 500

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Abstract

Background: The quality of chicken meat, essential for consumer satisfaction, is influenced by skin pigmentation. The lack of carotenoids in conventional diets motivates the search for cost-effective alternatives to enhance these aspects in poultry production. **Objective:** This study assessed the impact of partially replacing commercial balanced feed with different levels of carrot flour (*Daucus carota* subsp. *sativus*) on productive parameters and the pigmentation of broiler chickens. **Methods:** 64 Cobb 500 birds were randomly assigned to four experimental diets, each with eight replicates of two birds. The control group (T0) received a standard diet, while the experimental groups received a diet with 10 (T1), 15 (T2), and 20% (T3) replacement with carrot flour (CF). Variables such as feed consumption, weight gain, feed conversion, mortality, skin pigmentation, and profitability were evaluated. **Results:** Treatments with 15 and 20% carrot flour (CF) resulted in significantly higher feed consumption ($p < 0.05$) compared to the control group. Although weight gain did not show significant differences between groups ($p > 0.05$), a trend towards higher gains was observed in the experimental groups. The feed conversion ratio increased non-significantly ($p > 0.05$) with higher CF concentrations. No mortality was observed in the experimental groups, whereas the control group had a mortality rate of 12.5%. Regarding pigmentation, CF influenced skin color as its concentration in the diet increased. In terms of profitability, the 15% replacement treatment stood out by generating higher income and a superior cost-benefit ratio. **Conclusion:** Orange cultivar CF can be a viable dietary source of natural pigment for broiler chickens. It may also be beneficial in promoting weight gain and reducing mortality, translating into economic advantages.

Keywords: *Carotenoids; carrot; chicken feed; meat quality; natural pigment; profitability; skin color; yellow-skinned chicken.*

Resumen

Antecedentes: La calidad de la carne de pollo, esencial para la satisfacción del consumidor, se ve influida por la pigmentación de la piel. La falta de carotenoides en las dietas convencionales motiva la búsqueda de alternativas rentables para mejorar estos aspectos en la producción avícola. **Objetivo:** Este estudio evaluó el efecto de la sustitución parcial del alimento balanceado comercial con diferentes niveles de harina de zanahoria (*Daucus carota* subsp. *Sativus*) sobre los parámetros productivos y la pigmentación de los pollos de engorde. **Métodos:** 64 aves Cobb 500 fueron asignadas aleatoriamente a cuatro dietas experimentales con ocho repeticiones de dos aves cada una. El grupo control (T0) recibió una dieta estándar y los grupos experimentales una dieta con reemplazo del alimento balanceado en un 10 (T1), 15 (T2) y 20% (T3) por harina de zanahoria (HZ). Se evaluaron las variables consumo de alimento, ganancia de peso, conversión alimenticia, mortalidad, pigmentación de la piel y rentabilidad. **Resultados:** los tratamientos con 15 y 20% de HZ resultaron en un consumo de alimento significativamente mayor ($p < 0.05$) en comparación con el grupo control. Aunque la ganancia de peso no mostró diferencias significativas entre los grupos ($p > 0.05$), se observó una tendencia hacia mayores ganancias en los grupos con HZ. El índice de conversión alimenticia mostró un incremento no significativo ($p > 0.05$) con mayores concentraciones de HZ. Ninguno de los grupos experimentales presentó mortalidad, mientras que el grupo control tuvo una tasa de mortalidad del 12.5%. En cuanto a la pigmentación, la HZ influyó en la coloración de la piel a medida que aumentaba su concentración en la dieta. En relación con la rentabilidad, destacó el tratamiento con el 15% de reemplazo que generó mayores ingresos y un índice superior de beneficio/costo. **Conclusión:** La HZ del cultivar anaranjado puede ser una fuente dietética viable de pigmento natural para pollos de engorde. Además, puede resultar beneficioso en términos de ganancia de peso y menor pérdida por mortalidad, lo que se traduce en beneficios económicos.

Palabras clave: *Alimento para pollos; calidad de la carne; carotenoides; color de piel; pigmento natural; pollo de piel amarilla; zanahoria; rentabilidad.*

Resumo

Antecedentes: A qualidade da carne de frango, essencial para a satisfação do consumidor, é influenciada pela pigmentação da pele. A falta de carotenoides nas dietas convencionais motiva a busca por alternativas rentáveis para aprimorar esses aspectos na produção avícola. **Objetivo:** Este estudo avaliou o efeito da substituição parcial da ração comercial por diferentes níveis de farinha de cenoura (*Daucus carota* subsp. *Sativus*) sobre os parâmetros produtivos e a pigmentação de frangos de corte. **Métodos:** 64 aves da linhagem Cobb 500 foram aleatoriamente designadas a quatro dietas experimentais com oito réplicas de duas aves cada.

O grupo controle (T0) recebeu uma dieta padrão, e os grupos experimentais receberam uma dieta com substituição da ração em 10 (T1), 15 (T2) e 20 (T3) por farinha de cenoura (FC). Foram avaliadas as variáveis consumo de ração, ganho de peso, conversão alimentar, mortalidade, pigmentação da pele e rentabilidade. **Resultados:** Os tratamentos com 15 e 20% de farinha de cenoura (FC) resultaram em um consumo de ração significativamente maior (p < 0,05) em comparação com o grupo controle. Embora o ganho de peso não tenha mostrado diferenças significativas entre os grupos (p > 0,05), observou-se uma tendência de maiores ganhos nos grupos experimentais. O índice de conversão alimentar aumentou de forma não significativa (p > 0,05) com concentrações mais altas de FC. Nenhum dos grupos experimentais apresentou mortalidade, enquanto o grupo controle teve uma taxa de mortalidade de 12,5%. Quanto à pigmentação, a FC influenciou a coloração da pele conforme aumentava sua concentração na dieta. Em relação à rentabilidade, o tratamento com 15% de substituição destacou-se ao gerar maiores receitas e uma relação benefício/custo superior. **Conclusão:** A FC do cultivar alaranjado pode ser uma fonte dietética viável de pigmento natural para frangos de corte. Além disso, pode ser benéfica em termos de ganho de peso e menor perda por mortalidade, resultando em benefícios econômicos.

Palavras-chave: *carotenóides; cenoura; cor da pele; frango de pele amarela; lucratividade; pigmento natural; qualidade da carne.*

Introduction

Meat quality is a fundamental aspect of poultry production and plays a crucial role in marketing due to its close connection to consumer satisfaction (Baéza *et al*., 2022). High-quality meat encompasses sensory and nutritional properties. However, nutritional indicators cannot be known before consumption. Consumers tend to rely on sensory signals to predict food quality (de Araújo *et al*., 2022). Among these signals, skin pigmentation stands out as the most important attribute associated with freshness and is perceived as safe food (Qamar, 2019). Although, in practical terms, pigmentation does not guarantee food safety, its influence on the initial judgment of meat affects purchasing decisions, making it an important economic trait (de Araújo *et al*., 2022).

In Ecuador, there are preferences for a yellow skin color (Toalombo *et al*., 2019). However, the main broiler chicken breeds lack the genetic capacity to naturally develop the appropriate color intensity (Wu *et al*., 2021). As a result, poultry producers often add synthetic or natural pigments to the ingredients used to produce yellow-skinned chickens (Rana *et al*., 2021). However, synthetic pigments raise health and bioavailability concerns, while natural pigments are often not viable due to associated high costs (Martínez-Cámara *et al*., 2021). These limitations have led to a growing interest in the search for natural sources rich in carotenoids that are cost-effective for inclusion in bird diets (Pasarin & Rovinaru, 2018).

Previous studies (Dabai *et al*., 2021; Khan *et al*., 2019; Ng'Ambi *et al*., 2019; Muzaki *et al*., 2017; Ürüşan *et al*., 2018) have documented the potential of carrots to favor the quality of meat in Hubbard, Lohmann, and Arbor Acre chickens. At the same time, they observed significant improvements in productive performance. However, they do not specify the carrot subspecies used. This lack of specificity complicates the understanding of how different carrot subspecies could influence the observed results, as carrot (*Daucus carota L.*) is known for its richness in carotenoids, and the total content of these compounds varies according to the root color. Among these, orange cultivars stand out for having a ten times higher content of carotenoids (Perrin *et al*., 2017).

It is crucial to know which carrot subspecies has the desired effect in terms of pigmentation and bird performance to develop more effective and replicable feeding strategies. Additionally, to the best of our knowledge, no studies have been conducted on the impact of carrots on the meat quality of Cobb 500 chickens, suggesting the need for research on this genetic line before generalizing the observed benefits in other studies.

Thus, the main objective of this research was to evaluate the effect of carrot flour (*Daucus carota* subsp. *Sativus*) on the pigmentation, productive parameters, and profitability of Cobb 500 broiler chickens.

Materials and Methods

Ethical considerations

This study received approval from the Research Ethics Committee of Universidad Laica Eloy Alfaro de Manabí. It complies with the ethical regulations established for scientific research processes involving animals at the institution (RCU-SE-No.47-2016), which focuses on ensuring the animals' quality of life, providing suitable conditions for transportation and housing, and avoiding excessive manipulations that may cause suffering. The sacrifice process was conducted following the protocol established by the Agencia de Regulación y Control Fito y Zoosanitario de Ecuador (AGROCALIDAD, 2023).

Experiment location

The study was conducted at the Rio Suma Experimental Farm, located at the Faculty of Agricultural Engineering of the Laica Eloy Alfaro University of Manabí, El Carmen extension, Manabí province, Ecuador. The georeferential coordinates correspond to -0.262655 S and -79.427579 W, in an area characterized by a humid tropical climate. The agroecological properties in this area include an altitude of 260 meters above sea level, an air temperature in the shade of 24°C, an average annual precipitation of 190.98 mm, a relative humidity of 86%, 1,026 hours of sunlight exposure per year, and an annual evaporation of 1,064 mm (INAMHI, 2019).

Experimental Design

A total of 64 Cobb 500 broiler chickens were randomly assigned to three experimental diets and one control diet, with 8 replicates of 2 birds each. The treatments involved the partial substitution of commercial balanced feed with three levels of carrot flour (Table 1).

Table 1. Experimental Diets

Dietary Components	T0	T1	T2	T3
Commercial balanced feed (CBF)	100%	90%	85%	80%
Carrot flour (CF)	-	10%	15%	20%

Carrot Flour

Rejected orange-colored carrot roots (*Daucus carota* subsp. *sativus*) with aesthetic defects were purchased from a local producer in the Ambato canton (Tungurahua, Ecuador). Following the method of Hernández *et al*. (2015), the carrots were washed with 0.1% chlorinated water and cut into approximately 2 mm thick slices using a vegetable cutter (Sirman, model TM2 INOX). They were then dried at a temperature of 60°C for 20 hours in a dehydrator (Vikale model MQ-DH-10). Subsequently, the dried carrots were ground using a manual (Victoria mill, model 30018), yielding a 13.50% yield.

The nutritional values of the balanced feed used in diet formulation were obtained from the food composition table. To determine the nutritional composition of carrot flour, a sample was sent to the laboratory for bromatological analysis (Table 2). The total carotenoid content was determined by spectrophotometry at 450 nm (UV-VIS Spectrophotometer Model T6U-UV-VIS). The value of this parameter was 21.34 mg/100 g.

Table 2. Nutritional composition of commercial balanced feed and carrot flour (per 100 g)

Parameter	Balanced Feed	Carrot Flour	Method
(%) Moisture	13	9.2	AOAC, Ed. 21. 2019 934.01
(% DM) Protein	18	8.92	AOAC, Ed. 21. 2019 2001.11
(% DM) Crude Fat	5	1.34	AOAC, Ed. 21. 2019 920.39
(% DM) Ash	7	5.78	AOAC, Ed. 21. 2019 942.05
(% DM) Fiber	4	7.84	ISO 16472-2007

The formulated diets were neither isoproteic nor isoenergetic. Although no analysis was conducted on the dilution effect of the nutrients, it was estimated that the protein content varied, with protein values of 18% in T0, 17.1% in T1, 16.6% in T2, and 16.2% in T3, reflecting a reduction of 5% to 10%. Considering that the optimal protein range for Cobb 500 chickens is between 17% and 18% (Cobb-Vantress, 2018), the diets that included carrot meal remain within an acceptable limit.

Experimental Management

The birds, acquired at 5 days old with an initial weight of 45 g, were housed in a brooding circle until the tenth day. Subsequently, they were randomly distributed into experimental units. During the first 21 days, they were provided with the same standard diet formulated to meet nutritional requirements at each stage. From then on until they reached the target weight on day 39, they received commercial balanced feed with carrot flour according to the substitution levels. This represented a total experimental feeding period of 17 days. All birds were immunized against Newcastle disease, infectious bronchitis, and Gumboro disease. Additionally, they had free access to clean water and feed.

Evaluation Methodology

Throughout the 39 days the birds were kept in the poultry house, a daily record of food consumption was maintained, subtracting rejected food from the total provided. Weekly weight measurements were taken, and health status and mortality were monitored daily. Weighing was conducted at 7:00 a.m., prior to food supply. Subsequently, during the evaluation phase, the following productive parameters were calculated and analyzed for each treatment:

Cumulative Feed Consumption (g/bird). To estimate the amount of food each bird consumed over an experimental period; the total amount of food consumed was divided by the number of fed birds.

Cumulative Weight Gain (g/bird). To calculate the weight gain experienced by the birds, the initial weight was subtracted from the final weight.

Feed Conversion Ratio (FCR). Calculated by dividing the amount of food consumed by the weight gained. A lower feed conversion ratio indicates higher efficiency in converting food into body mass.

Mortality rate (%). Determined by dividing the number of dead birds by the number of birds at the beginning of the period.

Pigmentation. At the end of the experimental trial on day thirty-nine, birds were sacrificed using the bleeding method with manual cutting of the carotid arteries. Subsequently, scalding at 54 °C for 4 minutes and feather removal while keeping the skin intact were performed. Evaluation of the skin pigmentation of each bird, including those in the control group, was conducted after the evisceration process. The color intensity was measured using the Roche colorimetric fan, which uses a scale from 1 to 16. In this scale, 1 represents a nearly white tone, while 16 corresponds to a dark tomato tone, with intermediate gradations of yellow and tomato.

Profitability. Estimated through the benefit/cost ratio, applying the formula: B/C Ratio = (Income/Costs) x 100. Only feeding and vaccination costs were considered, along with income from the sale of chicken meat based on weight. A ratio > 1 indicates that the project is profitable.

Statistical analysis

The data were analyzed through the analysis of variance (ANOVA) technique and were presented in terms of mean values. To ensure the validity of the ANOVA, the normality of the data was first assessed using the Shapiro-Wilk test, and the results indicated that the data met the assumption of normality. For comparisons between the mean values, the Tukey test was applied, considering a significance level of $p < 0.05$. This process was executed using the Infostat statistical software version 2020.

Results

Productive parameters

As detailed in Table 3, chickens that received a diet composed of 90% CBF and 10% Carrot Flour (T1) and those that received a diet composed of 85% CBF and 15% Carrot Flour (T2) showed similar food consumption, which was significantly higher ($p < 0.05$) compared to the control group (T0). However, weight gain did not reach statistical significance ($p > 0.05$); nevertheless, it was observed that the experimental groups, particularly chickens in treatment T3, exhibited greater numerical weight gain than the control group (T0). Regarding the feed conversion ratio, it was observed that as the level of substitution with carrot flour increased, chickens showed a non-significant increase ($p > 0.05$) in conversion values, with variability among experimental groups. The best feed conversion ratio was observed in the control group followed by chickens in treatment T3. Regarding mortality, no losses were recorded in the groups of chickens that received diets with carrot flour. In contrast, the control group had a total of 2 deaths, equivalent to a mortality rate of 12.5%.

Table 3. Statistical comparison of productive parameters

Parameters	T0	T1	T2	T3
Cumulative feed consumption CBF + CF (g/bird)	3850.97[a]	4178.53[ab]	4323.41[b]	4350.35[b]
Cumulative weight gain (g/bird)	2489.69[a]	2555.13[a]	2704.06[a]	2780.94[a]
Feed conversion ratio CBF + CF	1.55[a]	1.64[a]	1.60[a]	1.56[a]
Mortality rate (%)	12.5	0.00	0.00	0.00

Means with a common letter are not significantly different ($p > 0.05$); CBF: Commercial balanced feed; CF: Carrot flour

Pigmentation

As observed in Table 4, increasing the concentration of carrot flour (*Daucus carota* subsp. *sativus*) resulted in progressively more intense pigmentation. The treatment with 10% carrot flour (T1) achieved a light pigmentation with a slight hint of yellow, while the treatment with 15% (T2) exhibited a pale-yellow color intensity. Likewise, the treatment with 20% carrot flour (T3) showed a more intense and defined yellow hue. In contrast, the control group (T0) exhibited very minimal pigmentation, leaning towards a white tone.

Table 4. Comparison of skin pigmentation variability in broiler chickens

Pigmentation	T0	T1	T2	T3
Average color Intensity (Scale: 1-16)	0.50	2.25	4.00	5.75

Profitability

Table 5 presents data related to the profitability analysis of each treatment. Regarding revenues, it is observed that treatment T2 recorded the highest figure, followed by treatment T3, T1, and T0. While treatment T3 exhibited the highest cost, followed by T2, T1, and T0. Similarly, it is noted that all treatments show B/C values above 1, indicating that they generate revenues surpassing associated costs, i.e., they are profitable. However, treatment T0 (control group) had the lowest B/C value. Overall, treatment T2 stood out for recording the highest revenues and a superior B/C ratio compared to the other treatments.

Table 5. Economic analysis

Metrics	T0	T1	T2	T3
Income (USD)	96,40	116,92	123,74	118,10
Costs (USD)	61,50	71,88	73,80	74,15
B/C (USD)	1,57	1,63	1,68	1,59

B/C: Benefit-Cost Ratio; USD: United States Dollar.

Discussion

The results of the study indicate that the partial substitution of balanced feed with carrot flour (*Daucus carota* subsp. *sativus*) in the diet of Cobb 500 broilers increases food intake and improves bird weight. These findings align with previous research by Ng'Ambi *et al*. (2019) and Noviadi & Maradon (2021), which also found positive effects on feeding behavior and weight gain when supplementing the Arbor Acre chicken diet with carrot flour.

According to Forbes (2010), in farm animals, increased food consumption of a particular diet compared to another can be attributed to its attractiveness in terms of palatability. In this regard, the chickens' response to food intake may be related to the palatability of the diet, driven by taste, texture, and the availability of nutrients such as carotenoids, vitamins, and minerals in carrot flour that stimulate consumption (Murugesan *et al*., 2021; Yunitasari *et al*., 2023).

Given that chickens consumed more food when including carrot flour in their diet, they could have ingested more calories overall, leading to greater weight gain (Silondae *et al*., 2023). However, the improvement in body weight was accompanied by a decrease in feed conversion efficiency. This coincides with the results of Muzaki *et al*. (2017), who observed that the inclusion of carrot waste flour in the diet of Lohmann chickens proportionally affected feed conversion efficiency.

As noted by Jha & Mishra (2021), one cause of this adverse effect on feed efficiency could be the fiber content in the diet. The author suggests that a diet with a high fiber content can reduce the digestibility of foods, so absorbed nutrients also decrease. Therefore, the problem in utilizing the CBF + CF mixture could be related to the increased fiber content, which is estimated at 7.84% in the carrot flour portion.

However, the variability in feed conversion efficiency among experimental groups suggests that while the chickens may have shown better adaptation or tolerance to the 10% carrot flour substitution level, other factors such as the interaction between diet nutrients, the physiological response of chickens to different ingredient proportions, and the management and maintenance parameters of each treatment could have influenced these results (Baracho *et al*., 2019; Jácome-Gómez *et al*., 2022).

The results of the productive parameters indicate that the reduction in protein intake did not have an adverse effect on the chickens' growth. This finding could be attributed to several factors, among which the ability of Cobb 500 chickens to adapt to diets with a lower amino acid density without compromising their performance stands out (Cobb-Vantress, 2018). Previous research has shown that Cobb 500 broilers can benefit from diets that do not necessarily meet the highest protein content, as long as other nutrients are available in adequate quantities and are highly digestible (Woyengo et al., 2023). Additionally, it is plausible that the increased feed intake allowed the chickens to reach the total nutrient intake necessary to sustain their growth and development, thus compensating for the reduction in dietary protein. However, further research is needed to confirm these results and understand why broiler chickens can maintain growth despite the reduction in protein content in their diets. Identifying the specific factors that enable this adaptation could further optimize dietary formulations and improve feed efficiency without compromising productive performance.

On the other hand, regarding mortality, chickens fed diets that included carrot meal, no deaths were recorded, whereas the control group had a total of 2 deaths. This observation is supported by the research of Silondae *et al*. (2023), which did not detect mortality in chickens fed diets containing carrots. According to Khan *et al*. (2023) and Nabi *et al*. (2020), carrots, due to their antioxidant and carotenoid content, could provide cellular protection to chickens by reducing oxidative stress and improving overall health. However, it is important to consider that other factors, such as management conditions, water quality, and overall chicken nutrition, could also have influenced the observed results, so further studies are needed to confirm this potential effect and determine the specific contribution of carrot meal to bird health.

Additionally, the results indicate that the carotenoids present in carrot meal (*Daucus carota* subsp. *Sativus*) have the potential to positively influence the skin coloration of broiler chickens. This aligns with the report by Wang *et al*. (2023), suggesting that poultry skin pigmentation is related to the intake of carotenoid pigments from their diet. However, it is important to note that not all studies have reached the same conclusions, such as the work of Azizah *et al*. (2017), which found no observable effects on the pigmentation of Lohmann broiler chickens when including carrot waste meal in their diets. Differences may be attributed to variability in the amount of carotenoids obtained from carrot waste and their level of incorporation into the supplied diet. Additionally, the study does not specify which carrot subspecies was used.

Regarding profitability, while we did not observe a substantial reduction in feeding costs, the average income per kg of chicken meat was USD 0.63, representing a 10% increase compared to conventionally fed chicken meat (USD 0.57). This indicates that using carrot meal as a substitute in the diet of broiler chickens can provide greater economic benefits. These results are particularly interesting as there are few studies specifically addressing profitability in relation to the use of carrots as a source of carotenoids in poultry feeding. The study by Chamba-Ochoa *et al*. (2020) is one of the few documented cases, and our results surpass their findings in terms of an increase in the cost-benefit ratio.

In summary, this study provides preliminary evidence of the potential benefits of incorporating carrot (*Daucus carota* subsp. *Sativus*) in the rearing of Cobb 500 broiler chickens. These benefits are reflected in both productive performance and economic profitability, presenting a viable alternative to reduce or eliminate the need for artificial pigments in poultry production. These findings are valuable for the feed industry and contribute to decision-making in formulating diets for the production of yellow-skinned chickens.

Nevertheless, further research is necessary to delve into the influence of key variables, such as the specific quantity and quality of carrot used in the birds' diet. Additionally, more detailed studies should increase the number of experimental units to enhance statistical power and reliability. It is also important to consider the sex of the birds as a potential source of variation, given its possible influence on performance and pigmentation outcomes. Moreover, experimental conditions—such as environmental, genetic, and management factors—can significantly impact the results obtained. Therefore, generalizing these findings is premature. Future studies will contribute to a more comprehensive understanding of how the inclusion of carrot meal affects the performance and skin pigmentation of broiler chickens, providing more specific information for optimizing nutritional strategies in the production of yellow-skinned chickens.

Declarations

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

Authors' contributions

JJG: Study design, project administration, data collection, manuscript review, and writing. MDLC: Data processing, formal analysis, interpretation of data, and manuscript writing. JEZ and GLM: Methodology, preparation of carrot meal, bromatological analysis, and manuscript writing. MZR and JIV - Conceptualization, economic analysis, and manuscript writing. All authors contributed to the critical revision and approved the final version of the manuscript.

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Use of artificial intelligence (AI)

No AI technologies or AI-assisted technologies were used during the preparation of this work.

References

AGROCALIDAD (Agencia de Regulación y Control Fito y Zoosanitario de Ecuador). Bienestar animal, faenamiento de animales de producción. Ecuador. 2023. https://www.agrocalidad.gob.ec/wp-content/uploads/2023/03/Faenamiento_compressed.pdf

Azizah NA, Mahfudz LD, Sunarti D. Kadar lemak dan protein karkas ayam broiler akibat penggunaan tepung limbah wortel (Daucus carota L.) dalam Ransum. J Sain Peternaka Indonesia 2017; 12(4): 389-396. https://doi.org/10.31186/jspi.id.12.4.389-396

Baéza E, Guillier L, Petracci, M. Production factors affecting poultry carcass and meat quality attributes. Anim 2022; 16: 100331. https://doi.org/10.1016/j.animal.2021.100331

Baracho MS, Nääs IDA, Lima NDS, Cordeiro A FS, Moura DJ. Factors affecting broiler production: A meta-analysis. Braz J Poult Sci 2019; 21(03): 001-010. https://doi.org/10.1590/1806-9061-2019-1052

Chamba-Ochoa H, Cordero-Salazar F, Vacacela-Ajila W, Ortega-Rojas R, Solórzano-Castillo J, Benítez-González E. Efecto de zanahoria (Daucus carota) y alfalfa (Medicago sativa) en pigmentación de carne de pollo. Bosq Lat Cero 2020; 10(1): 39-45. https://revistas.unl.edu.ec/index.php/bosques/article/view/717

Cobb Vantress. Cobb 500: Suplemento informativo sobre rendimiento y nutrición de pollos de engorde. Arkansas: Cobb Vantress; 2018. https://colaves.com/project/pollos-cobb-de-engorde/

Dabai SA, Bello S, Dabai JS. Growth performance and carcass characteristics of finisher broiler chickens served carrot leaf extract as a supplementary source of vitamins and minerals. Nigerian J Anim Sci 2021; 23(1): 144-149. https://www.ajol.info/index.php/tjas/article/view/212020

de Araújo PD, Araújo WMC, Patarata L, Fraqueza MJ. Understanding the main factors that influence consumer quality perception and attitude towards meat and processed meat products. Meat Sci 2022; 193: 108952. https://doi.org/10.1016/j.meatsci.2022.108952

Di Rienzo, J. A., Casanoves, F., Balzarini, M. G., González, L., Tablada, M., & Robledo, C. W. (2020). InfoStat versión 2020. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. https://www.infostat.com.ar/index.php?mod=page&id=46

Forbes JM. Palatability: principles, methodology and practice for farm animals. CABI Revi 2010; 5(52): 1-15. https://doi.org/10.1079/PAVSNNR20105052

Hernández RRM, Blanco DJ. Evaluación de polvos de zanahoria obtenidos por deshidratación por aire forzado a diferentes temperaturas. Idesia Arica 2015; 33(4): 75-80. http://dx.doi.org/10.4067/S0718-34292015000400010

INAMHI (Instituto Nacional de Meteorología e Hidrología). Precipitación-2019 Diciembre.csv. Ecuador. 2019. https://www.datosabiertos.gob.ec/dataset/precipitacion-total-mensual/resource/98c77d18-e863-4e00-8a22-eb47f2981d9c

Jácome-Gómez JR, Sánchez EJS, Mendoza MEZ, De la Cruz CMV, Anchundia MAM. Efecto de diferentes materiales de cama sobre el comportamiento productivo de pollos de engorde Cobb 500. Cien La Rev Cient Multidisc 2022; 6(5): 3868-3881. https://doi.org/10.37811/cl_rcm.v6i5.3362

Jha R, Mishra P. Dietary fiber in poultry nutrition and their effects on nutrient utilization, performance, gut health, and on the environment: a review. J Anim Sci Biotech 2021; 12(51): 1-16. https://doi.org/10.1186/s40104-021-00576-0

Khan RU, Khan A, Naz S, Ullah Q, Puvača N, Laudadio V, Mazzei D, Seidavi A, Ayasan T, Tufarelli V. Pros and Cons of Dietary Vitamin A and Its Precursors in Poultry Health and Production: A Comprehensive Review. Antiox 2023; 12(5): 1131. https://doi.org/10.3390/antiox12051131

Martínez-Cámara S, Ibañez A, Rubio S, Barreiro C, Barredo JL. Main carotenoids produced by microorganisms. Encycl 2021; 1(4): 1223-1245. https://doi.org/10.3390/encyclopedia1040093

Murugesan K, Srinivasan KR, Paramasivam K, Selvam A, Wong J. Conversion of Food Waste to Animal Feeds. In: Current Developments in Biotechnology and Bioengineering. Elsevier; 2021; p.05-324. https://doi.org/10.1016/B978-0-12-819148-4.00011-7

Muzaki MDR, Mahfudz LD, Muryani R. The Effect of Waste carrot Product (Daucus Carrota L) Powder in The Diet on Broiler Chickens Performance. J Ilmu Ternak 2017; 17(1): 14-20. https://jurnal.unpad.ac.id/jurnalilmuternak/article/view/14798/7049

Nabi F, Arain MA, Rajput N, Alagawany M, Soomro J, Umer M, Soomro F, Wang Z, Ye R, Liu J. Health benefits of carotenoids and potential application in poultry industry: A review. J Anim Physiol Anim Nutr 2020; 104(6): 1809-1818. https://doi.org/10.1111/jpn.13375

Ng'Ambi JW, Mokgope PK, Brown D, Manyelo TG. Effect of dietary carrot meal supplementation on productivity and carcass characteristics of Arbor acre broiler chickens aged 22 to 42 days. Appl Ecol Environ Res 2019; 17(5) 12337-12346. https://aloki.hu/pdf/1705_1233712346.pdf

Noviadi R, Maradon GG. Broiler performance given carrot waste juice meal as a feed supplement. International Conference on Agriculture and Applied Science; 2020 Nov 19; Politeknik, Negeri. Lampung: ICoAAs; 2021. https://doi.org/10.25181/icoaas.v1i1.2068

Pasarin D, Rovinaru C. Sources of carotenoids and their uses as animal feed additives-a review. The International Session of Scientific Communications of the Faculty of Animal Science; Independentei, Bucarest, Romania: Scientific Papers Series D Animal Science; 2018.https://animalsciencejournal.usamv.ro/pdf/2018/issue_2/Art12.pdf

Perrin F, Hartmann L, Dubois-Laurent C, Welsch R, Huet S, Hamama L, Briard M, Peltier D, Gagné S, Geoffriau E. Carotenoid gene expression explains the difference of carotenoid accumulation in carrot root tissues. Planta 2017; 245: 737–74. https://doi.org/10.1007/s00425-016-2637-9

Qamar A. Physical and chemical factors affecting chicken meat color. Pak J Sci 2019; 71(2): 82-88. https://doi.org/10.57041/pjs.v71i2.268

Rana B, Bhattacharyya M, Patni B, Arya M, Joshi GK. The realm of microbial pigments in the food color market. Front Sustain Food Syst 2021; 5: 603892. https://doi.org/10.3389/fsufs.2021.603892

Silondae H, Polakitan D, Paat PC, Kairupan AN, Layuk P, Lintang M, Joseph GH, Polakitan A, Tandi OG, Rawung JBM, Rembang JHW, Salamba HN, Malia IE, Sondakh JOM, Hutapea

RTP, Kindangen JG, Elizabeth R. The effects of carrot (Daucus carota L.) waste juice on the performances of native chicken in North Sulawesi, Indonesia. Op Agric 2023; 8(1): 20220173. https://doi.org/10.1515/opag-2022-0173

Toalombo PA, Camacho CA, Buenaño R, Jiménez S, Navas-González FJ, Landi V, Delgado JV. Efecto socioeconómico sobre las características fanerópticas de gallinas autóctonas de Ecuador. Arch Zoot 2019; 68(263): 416-421. https://doi.org/10.21071/az.v68i263.4202

Ürüşan H, Erhan M, Bölükbaşı SC. Effect of cold-press carrot seed oil on the performance, carcass characteristics, and shelf life of broiler chickens. JAPS: J Anim Plant Sci 2018; 28(6): 1692-1668. https://thejaps.org.pk/docs/v-28-06/17.pdf

Wang Y, Gan S, Luo C, Liu S, Ma J, Luo W, Lin C, Shu D, Qu H. Variations in BCO2 Coding Sequence Causing a Difference in Carotenoid Concentration in the Skin of Chinese Indigenous Chicken. Genes 2023; 14(3): 671. https://doi.org/10.3390/genes14030671

Woyengo TA, Knudsen KB, Børsting CF. Low-protein diets for broilers: current knowledge and potential strategies to improve performance and health, and to reduce environmental impact. Anim Feed Sci and Tech 2023; 297, 115574. https://doi.org/10.1016/j.anifeedsci.2023.115574

Wu J, Lin Z, Chen G, Luo Q, Nie Q, Zhang X, Luo W. Characterization of chicken skin yellowness and exploration of genes involved in skin yellowness deposition in chicken. Front in Physiol 2021; 12: 585089. https://doi.org/10.3389/fphys.2021.585089

Yunitasari F, Jayanegara A, Ulupi N. Performance, egg quality, and immunity of laying hens due to natural carotenoid supplementation: A meta-analysis. Food Sci Anim Resour 2023; 43(2), 282. https://doi.org/10.5851/kosfa.2022.e76