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The evaluation of orange pulp meal levels as a pedagogical strategy for the development of competencies in agricultural education

La evaluación de niveles de harina de pulpa de naranja como estrategia pedagógica para el desarrollo de competencias en la formación agropecuaria

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ABSTRACT

Competency-based agricultural education requires pedagogical strategies that integrate applied research with meaningful learning. In this context, the evaluation of orange pulp meal levels in the diet of laying hens represents not only a nutritional alternative but also a valuable formative opportunity. The objective of this study was to analyze the evaluation of different orange pulp meal inclusion levels as a pedagogical strategy for competency development in agricultural education. The research followed a mixed-methods approach, combining an experimental design to assess productive variables with a qualitative analysis focused on student performance. Different inclusion levels of the citrus by-product were evaluated, recording productive indicators such as egg production, feed intake, and feed conversion. Simultaneously, the development of technical and research competencies was assessed through performance-based evaluation, analytical rubrics, and evidence portfolios. The results showed that low and medium inclusion levels maintained productive performance comparable to the control treatment, while higher levels tended to negatively affect some indicators. From a pedagogical perspective, significant competency development was observed, particularly in knowledge application, result analysis, and technical decision-making. It is concluded that evaluating orange pulp meal inclusion levels constitutes a relevant pedagogical strategy to strengthen competency-based training in agricultural education.

Keywords: competency-based education; agricultural education; poultry nutrition; experiential learning; citrus by-products.

RESUMEN

La formación agropecuaria basada en competencias requiere estrategias pedagógicas que integren la investigación aplicada con el aprendizaje significativo. En este contexto, la evaluación de niveles de harina de pulpa de naranja en la dieta de aves ponedoras representa no

solo una alternativa nutricional, sino también una oportunidad formativa. El objetivo de este estudio fue analizar la evaluación de diferentes niveles de harina de pulpa de naranja como estrategia pedagógica para el desarrollo de competencias en la formación agropecuaria. La investigación se desarrolló bajo un enfoque metodológico mixto, combinando un diseño experimental para el análisis de variables productivas con un análisis cualitativo orientado a la valoración del desempeño estudiantil. Se evaluaron distintos niveles de inclusión del subproducto cítrico, registrándose indicadores productivos como producción de huevos, consumo y conversión alimenticia. Paralelamente, se valoró el desarrollo de competencias técnicas e investigativas mediante evaluación basada en el desempeño, rúbricas analíticas y portafolios de evidencias. Los resultados mostraron que los niveles bajos y medios de inclusión de harina de pulpa de naranja mantuvieron un desempeño productivo comparable al tratamiento control, mientras que niveles elevados tendieron a afectar algunos indicadores. Desde el punto de vista pedagógico, se evidenció un desarrollo significativo de competencias, especialmente en la aplicación de conocimientos, análisis de resultados y toma de decisiones técnicas. Se concluye que la evaluación de niveles de harina de pulpa de naranja constituye una estrategia pedagógica pertinente para fortalecer la formación por competencias en la educación agropecuaria.

Palabras clave: formación por competencias; educación agropecuaria; nutrición aviar; aprendizaje experimental; subproductos cítricos.

1. Introduction

The contemporary agricultural education system faces the challenge of simultaneously responding to the productive demands of the sector and the need to train competent professionals capable of analyzing, innovating, and making evidence-based decisions in real contexts. In this regard, the competency-based training approach has gained increasing relevance, as it prioritizes the integration of theoretical knowledge with experimental practice, critical thinking, and contextualized problem-solving. Various authors agree that experiential learning and the active participation of students in research processes significantly strengthen the development of professional competencies in higher and technical agricultural education (Kolb, 1984; Biggs & Tang, 2011).

In the field of poultry production, animal nutrition constitutes a fundamental axis both from a productive and educational perspective. The search for alternative feed sources that reduce costs, improve sustainability, and utilize agro-industrial by-products has been widely documented in scientific literature. In particular, citrus by-products, such as orange pulp meal, have shown significant potential as an ingredient in poultry diets, provided they are used at appropriate inclusion levels (Bampidis & Robinson, 2006; Mathlouthi & Leeson, 1997). Previous studies have demonstrated that moderate incorporation of citrus pulp can maintain acceptable production parameters, whereas excessive levels may affect feed intake and efficiency (Oluremi et al., 2010; Chaib et al., 2024).

Nevertheless, much of the research on the use of citrus by-products in poultry feeding has focused exclusively on productive outcomes, leaving aside their potential as pedagogical tools within training processes. From an educational perspective, evaluating different inclusion levels of orange pulp meal constitutes a privileged didactic scenario, as it allows students to actively participate in experimental design, diet formulation, data recording and analysis, as well as in the critical interpretation of results. These experiences align with the principles of problem-based learning and performance-based assessment, strategies widely recognized for their effectiveness in developing professional competencies (Creswell & Plano Clark, 2018; Galt et al., 2012).

Furthermore, the integration of applied research into agricultural education fosters the development of technical, investigative, and reflective competencies essential for professional practice. Performance evaluation in real contexts, supported by instruments such as analytical rubrics and evidence portfolios, enables assessment not only of final results but also of learning processes and the student's ability to justify technical decisions based on scientific evidence (Brumm et al., 2006; Díaz et al., 2019). From this perspective, research acquires dual value: productive and pedagogical.

In this context, it is necessary to deepen studies that integrate the nutritional evaluation of alternative ingredients with a pedagogical analysis of the formative processes they generate. Therefore, the present article aims to analyze the evaluation of orange pulp meal inclusion levels in laying hen diets as a pedagogical strategy for competency development in agricultural education. The research is based on a mixed methodological approach, which allows the articulation of quantitative results derived from the experiment with a qualitative interpretation oriented toward the assessment of meaningful learning and the development of professional competencies, thus contributing both to scientific knowledge and to educational innovation in the agricultural field.

2. Materials and methods

The research was conducted under a mixed methodological approach, integrating quantitative experimental procedures with a qualitative pedagogical analysis. This combination allowed for the evaluation, on the one hand, of the effects of different levels of orange pulp meal in the diet of laying hens, and on the other, for the analysis of the formative value of this experimental process as a pedagogical strategy for the development of competencies in agricultural education. The mixed design adopted was concurrent, since both dimensions were addressed in a parallel and integrated manner during the course of the study.

From the quantitative perspective, the research corresponded to an experimental design, oriented toward the evaluation of inclusion levels of orange pulp meal in the feeding of laying hens. Treatments were established with different percentages of inclusion of the citrus by-product in the diets, maintaining controlled conditions of management, health, and environment, in order to analyze its impact on productive variables. In parallel, from the qualitative perspective, a pedagogical analysis of the experimental process was carried out, considering the participation of students in the different phases of the research and their contribution to the development of technical, investigative, and reflective competencies.

Population and sample

The study population consisted of laying hens in their productive stage, managed within a controlled production system. The sample was selected through purposive sampling, based on zootechnical criteria such as age, health status, and productive homogeneity, which ensured the validity of the experimental results. The hens were randomly distributed into experimental groups corresponding to each level of orange pulp meal inclusion, guaranteeing equality in the number of individuals per treatment.

In the pedagogical component, the sample was composed of agricultural science students who actively participated in the design, execution, and analysis of the experiment. Their selection was based on criteria of accessibility and academic relevance, given that the study was carried out in a formative context where experimentation constitutes a fundamental axis of practical learning.

Materials

For the development of the experiment, laying hens were used along with poultry facilities suitable for their management, feeders and drinkers, as well as conventional feed inputs employed in diet formulation. Orange pulp meal was obtained as an agro-industrial by-product, previously processed and conditioned for use in animal feeding. Additionally, scales were used for recording feed intake and weight, daily production records, and laboratory materials necessary for controlling the evaluated variables.

In the pedagogical domain, instruments such as analytical rubrics, observation records, and evidence portfolios were employed. These tools made it possible to document student performance during the experimental process, as well as their reflections and learning outcomes derived from the experience.

Procedures and methods

The experimental procedure began with the formulation of diets incorporating different levels of orange pulp meal, which were supplied to the hens over a defined period, following a previously established protocol. During this phase, productive variables such as feed intake, egg production, and other relevant indicators were recorded and subjected to quantitative analysis to identify possible differences among treatments.

Simultaneously, the experimental process was used as a pedagogical strategy, allowing students to actively participate in all stages of the study, from problem definition to the interpretation of results. The evaluation of competency development was carried out through performance-based assessment, supported by rubrics that considered criteria such as application of knowledge, management of technical procedures, critical analysis of results, and argumentative capacity. The evidence portfolio made it possible to assess the formative process in an integral manner, while guided reflection facilitated the qualitative analysis of the meaningful learning achieved.

Information Analysis

The quantitative data obtained from the experiment were organized and analyzed using descriptive and comparative statistical procedures, which allowed for the evaluation of the effect of different levels of orange pulp meal on the productive performance of laying hens. Meanwhile, the qualitative information derived from observations, rubrics, and portfolios was analyzed through a process of reflective interpretation, aimed at identifying evidence of competency development in agricultural training.

The integration of both approaches enabled a comprehensive understanding of the phenomenon under study, articulating the productive results with their pedagogical value and strengthening the relevance of the research in both the scientific and educational domains.

3. Results

Los resultados de la investigación se presentan de manera integrada, considerando tanto los hallazgos cuantitativos

derivados de la evaluación de diferentes niveles de harina de pulpa de naranja en la dieta de aves ponedoras, como los resultados cualitativos relacionados con el desarrollo de competencias en la formación agropecuaria. Esta integración permitió analizar el impacto productivo de las dietas evaluadas y, simultáneamente, valorar el proceso formativo asociado a la experiencia experimental.

Table 1. Average Egg Production According to Orange Pulp Meal Inclusion Level

Treatment	Inclusion Level (%)	Average Production (%)
T1	0 (control)	High
T2	Low level	Similar to control
T3	Medium level	Slightly higher
T4	High level	Tendency to decrease

Source: Own elaboration

The analysis of the results showed that treatments with low and medium levels of orange pulp meal inclusion presented egg production comparable to, and even slightly higher than, the control treatment. In contrast, higher levels exhibited a tendency toward decreased productivity. These findings indicated that moderate inclusion of the by-product did not negatively affect productive performance, allowing students to understand the importance of establishing appropriate inclusion levels in diet formulation and strengthening their capacity for technical analysis and evidence-based decision-making.

Table 2. Average Feed Intake per Hen by Treatment

Treatment	Average Intake
T1	Normal
T2	Similar
T3	Slightly lower
T4	Greater variability

Source: Own elaboration

The results showed that feed intake remained relatively stable in the treatments with low and medium levels of orange pulp meal, while the treatment with the highest level presented greater variability. This behavior suggested that excessive inclusion of the by-product may have influenced the palatability of the diet. From a pedagogical perspective, this outcome fostered students' critical analysis of the relationship between diet formulation, feed intake, and productive performance.

Table 3. Feed Conversion in Laying Hens According to Inclusion Level

Treatment	Feed Conversion
T1	Efficient
T2	Similar
T3	More efficient
T4	Less efficient

Source: Own elaboration

Feed conversion showed better performance in the treatments with intermediate levels of orange pulp meal, evidencing a more efficient utilization of the feed. In contrast, higher levels presented a less favorable conversion. This result allowed students to interpret key productive indicators and to understand the need to balance nutritional benefits with the possible negative effects of excessive inclusion.

Table 4. Level of Development of Technical Competencies According to Performance Rubric

Competency Evaluated	Level Achieved
Diet formulation	High
Experimental management	High
Data recording	Medium–high
Results interpretation	High

Source: Own elaboration

The rubric analysis revealed a high level of development in technical competencies related to diet formulation and experimental management. Students demonstrated mastery in applying procedures as well as in controlling productive variables. These results confirmed that performance-based assessment was an effective strategy to evaluate the "know-how" in real contexts, thereby strengthening competency-based training.

Table 5. Evidence of Research Competencies Recorded in the Portfolio

Indicator	Achievement Level
Literature analysis	Adequate
Data systematization	High
Technical argumentation	High
Critical reflection	Medium–high

Source: Own elaboration

The evidence portfolios showed that students successfully integrated theoretical knowledge with experimental practice, standing out in the quality of technical argumentation and results analysis. Although critical reflection reached a slightly lower level, a significant progression was evident throughout the process.

These findings highlight the value of the portfolio as a pedagogical tool to continuously and formatively assess learning, since it allowed documenting not only the achievements attained but also the evolution of critical thinking and research capacity. Overall, the portfolio was consolidated as a key instrument to make visible meaningful learning and the development of competencies in real contexts of agricultural experimentation.

Table 6. Perception of Significant Learning Associated with the Experimental Process

Category	Observed Trend
Theory–practice relationship	Very high
Motivation for research	High
Understanding of the productive context	Very high

Source: Own elaboration

The qualitative analysis of observations and reflections made it possible to identify a positive perception of meaningful learning. Students expressed a greater understanding of the relationship between theory and practice, as well as increased motivation toward applied research. This result confirmed that the evaluation of orange pulp meal inclusion levels not only generated relevant productive data but also constituted an effective pedagogical strategy to contextualize learning and strengthen professional competencies.

Taken together, the results showed that moderate inclusion of orange pulp meal in the diet of laying hens was viable from a productive standpoint and, at the same time, that the experimental process functioned as an effective pedagogical strategy for the development of technical, research, and reflective competencies in agricultural training. The integration of quantitative and qualitative results allowed for a comprehensive understanding of the phenomenon studied, reinforcing both the scientific and educational relevance of the research.

4. Discussion

The results obtained in this research showed that the evaluation of different levels of orange pulp meal in the diet of laying hens not only had relevant productive implications but also constituted an effective pedagogical strategy for the development of competencies in agricultural training. From a nutritional standpoint, the findings confirmed that low and medium levels of inclusion of the citrus by-product allowed productive parameters comparable to the control treatment to be maintained, while higher levels tended to negatively affect some indicators, such as feed conversion and intake stability. These results are consistent with those reported by Bampidis and Robinson (2006), who noted that citrus by-products can be efficiently used in animal feeding as long as appropriate inclusion limits are respected.

Similarly, the results obtained were coherent with previous studies that have warned that the fiber present in citrus pulp, although it may provide nutritional benefits, can also generate adverse effects when excessively incorporated into poultry diets (Mathlouthi & Leeson, 1997; Summers & Leeson, 1992). In this sense, the experimental evaluation allowed students to understand the complexity of diet formulation and the need to balance nutritional, productive, and economic criteria, reinforcing the formative value of the research process.

From a pedagogical perspective, the qualitative results evidenced significant development of technical and research competencies, particularly in relation to diet formulation, experimental management, and results interpretation. These findings support the arguments of Kolb (1984), who emphasized that experiential learning fosters knowledge construction through reflective practice. Likewise, the high valuation of the theory–practice relationship observed in students coincides with what was stated by Biggs and Tang (2011), who argue that quality learning occurs when formative activities are aligned with authentic and contextualized learning outcomes.

The use of performance-based assessment, supported by analytical rubrics and evidence portfolios, allowed for a comprehensive evaluation of competency development beyond the mere acquisition of theoretical knowledge. This approach is consistent with the recommendations of Brumm et al. (2006) and Díaz et al. (2019), who underline the importance of assessing professional competencies based on observable performance in real contexts. In this study, the active participation of students in all phases of the experiment fostered autonomy, technical argumentation, and well-founded decision-making—essential aspects in agricultural training.

The adoption of a mixed methodological approach proved pertinent to understanding the complexity of the phenomenon studied. The integration of quantitative data derived from the experiment with the qualitative analysis of the formative process provided a broader and deeper view of the results, in line with the proposals of Creswell and Plano Clark (2018) and Teddlie and Tashakkori (2009). This methodological complementarity strengthened the validity of the study, showing that productive and pedagogical

results should not be analyzed in isolation but as interrelated dimensions of the same formative process.

Furthermore, the findings of this study aligned with research highlighting the potential of agricultural education to promote competencies related to sustainability and the efficient use of local resources (Galt et al., 2012). The evaluation of orange pulp meal as an alternative ingredient allowed students to reflect on the use of agro-industrial by-products, strengthening a critical and responsible vision of the productive system—an increasingly relevant aspect in the training of professionals in the sector.

Overall, the discussion of results confirmed that the evaluation of orange pulp meal inclusion levels transcended its initial experimental purpose, consolidating itself as a pedagogical strategy consistent with the principles of competency-based training. The articulation between applied research and the formative process fostered the development of technical, research, and reflective skills, contributing to agricultural education that is more relevant, contextualized, and oriented toward the real demands of the productive environment.

5. Conclusions

The evaluation of different levels of orange pulp meal in the diet of laying hens confirmed that moderate inclusion of this agro-industrial by-product is viable from a productive standpoint, since it did not negatively affect the main performance indicators. On the contrary, higher levels tended to generate unfavorable variations in parameters such as feed intake and feed conversion, reaffirming the need to establish rigorous technical criteria in diet formulation. These results provide relevant scientific evidence for the responsible use of citrus by-products in poultry nutrition.

From a pedagogical perspective, the experimental process was consolidated as an effective strategy for the development of competencies in agricultural training. The active participation of students in the design, execution, and analysis of the experiment fostered the integration of theoretical knowledge with productive practice, strengthening technical, research, and decision-making competencies. Performance-based assessment, supported by analytical rubrics and evidence portfolios, allowed for a comprehensive evaluation of the learning achieved and highlighted significant progress in the understanding of the real productive context.

The adoption of a mixed methodological approach made it possible to coherently articulate the quantitative results derived from the nutritional evaluation with the qualitative analysis of the formative process. This integration favored a broader understanding of the phenomenon studied, demonstrating that applied research in animal nutrition can fulfill a dual function: generating scientific knowledge and strengthening competency-based training processes in agricultural education.

Taken together, the study's findings confirm that the evaluation of orange pulp meal inclusion levels transcends its technical–productive contribution, becoming a pedagogical strategy relevant for the training of competent, critical, and contextualized agricultural professionals. The incorporation of such experiences into formative processes contributes to more meaningful education, aligned with the demands of the productive sector and with the principles of sustainability and efficient use of local resources.

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Authors Contribution:

The authors Josué Omar Mendoza Montoya, Jaime Onan Salgado Mejía, Elky Marcela Bock Argueta, Keisy Bianey Peralta Matute, Dani Oved Ochoa Cervantez, Flavio José Hernández Bonilla, and Jhunior Marcia Fuentes declare that they have actively and significantly participated in the development of this article, meeting the international criteria for scientific authorship.

All authors contributed to the conception and design of the study, as well as to the collection, analysis, and interpretation of the information derived from the research. They also participated in drafting the manuscript, critically reviewing its intellectual content, and approving the final version for publication, assuming shared responsibility for the integrity and accuracy of the data presented.

The authors state that the work is original, has not been previously published, and is not under review in another scientific journal. Likewise, they declare that there are no personal, academic, or institutional conflicts of interest that may have influenced the results or interpretations presented in the article.

Finally, the authors assume full ethical and academic responsibility for the content of the manuscript, ensuring compliance with the principles of scientific honesty, methodological rigor, and respect for current editorial standards.