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Economic and Nutritional Evaluation of Calcium and Phosphorus Sources in Layer and Breeder Diets under High Calcium Conditions

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Abstract: Calcium (Ca) and phosphorus (P) are critical minerals in layer and breeder nutrition, directly influencing eggshell quality, skeletal integrity, and reproductive performance. This study evaluates the economic and nutritional implications of using different inorganic phosphate sources, including Monocalcium Phosphate (MCP), Dicalcium Phosphate (DCP), and Calcium Carbonate (limestone), in diets formulated to contain approximately 4.4% Ca and 0.41–0.42% P. Three mineral supplementation strategies were compared: MCP + limestone, DCP + limestone, and a combined MCP + DCP + limestone system. Results showed that DCP-based formulations had the lowest direct cost, while MCP-based formulations had the highest. The combined MCP + DCP strategy provided an intermediate cost with improved phosphorus bioavailability. Economic evaluation demonstrated that the cost increase associated with MCP inclusion is minimal when expressed as a percentage of total feed cost (~0.3–0.8%) and can be offset by improvements in biological performance. The study highlights the importance of evaluating mineral sources based on available phosphorus, physiological efficiency, and production output, rather than cost alone.

Keywords: Calcium nutrition, phosphorus bioavailability, layer diets, breeder nutrition, monocalcium phosphate (MCP), dicalcium phosphate (DCP).

Research Paper

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1. INTRODUCTION

Calcium and phosphorus are essential macrominerals in poultry nutrition, particularly in layer and breeder systems where high rates of egg production impose substantial mineral demands. Calcium is required primarily for eggshell formation, while phosphorus plays a critical role in bone metabolism, energy utilization, and reproductive performance (National Research Council, 1994).

Layer diets typically contain high levels of calcium (~3.5–4.5%), supplied mainly by limestone. Phosphorus is supplemented through inorganic phosphates such as MCP and DCP. These sources differ in chemical structure, solubility, digestibility, and cost, which directly influence their nutritional and economic value (Potter, 1988).

Under high-calcium conditions, phosphorus availability becomes a limiting factor due to interactions between calcium and phosphorus in the digestive tract. Therefore, the selection of phosphate source is critical for optimizing both nutrient utilization and production performance biology.

This study aims to evaluate different mineral supplementation strategies in layer and breeder diets from both economic and biological perspectives, with particular emphasis on phosphorus bioavailability and its interaction with dietary calcium.

2. MATERIALS AND METHODS

2.1 Mineral Composition and Prices

Ingredient	Ca (%)	P (%)	Price (SDG/kg)
MCP	18	22	7,500
DCP	22	18	5,700
Limestone	37	0	230

2.2 Target Nutrient Levels

All formulations were designed to achieve:
Calcium ≈ 4.4%
Phosphorus ≈ 0.41–0.42%
Total mineral inclusion = 129 kg

2.3 Formulation Scenarios

Three mineral supplementation strategies were evaluated:
MCP + Limestone MCP + DCP + Limestone DCP + Limestone

3. RESULTS
3.1 MCP + DCP + Limestone

Ingredient	Kg	Ca	P	Cost (SDG)
MCP	9	0.162	0.198	67,500
DCP	12	0.264	0.216	68,400
Limestone	108	3.996	0	24,840
Total	129	4.422	0.414	160,740

3.2 MCP + Limestone

Ingredient	Kg	Ca	P	Cost (SDG)
MCP	19	0.342	0.418	142,500
Limestone	110	4.070	0	25,300
Total	129	4.412	0.418	167,800

3.3 DCP + Limestone

Ingredient	Kg	Ca	P	Cost (SDG)
DCP	23	0.506	0.414	131,100
Limestone	106	3.922	0	24,380
Total	129	4.428	0.414	155.480

4. Economic Analysis
4.1 Total Cost Comparison

Strategy	Total Cost (SDG)
DCP + Limestone	155,480
MCP + DCP + Limestone	160,740
MCP + Limestone	167,800

Relative to DCP-based formulation:
MCP + DCP: +3.4%
MCP only: +7.9%

4.2 Cost per kg Mineral Mix

Strategy	Cost/kg (SDG)
DCP + Limestone	1,205
MCP + DCP + Limestone	1,246
MCP + Limestone	1,301

4.3 Impact on Total Feed Cost
Since minerals represent approximately 10% of total feed cost:
MCP + DCP increases total feed cost by only ~0.3–0.4%
MCP-only increases total feed cost by ~0.7–0.8%

5. Bioavailability and Nutritional Evaluation
5.1 Phosphorus Availability
Phosphorus from MCP is more soluble and digestible than from DCP, resulting in higher biological availability (Potter, 1988). Therefore, evaluating mineral sources based on total phosphorus content alone may underestimate the nutritional value of MCP.

5.2 Calcium–Phosphorus Interaction
High dietary calcium levels:
Reduce phosphorus digestibility
Promote formation of insoluble Ca–P complexes
Limit phytate phosphorus utilization (Selle & Ravindran, 2007)
Under these conditions, more soluble phosphorus sources improve nutrient efficiency (Potter, 1988; Selle & Ravindran, 2007).

5.3 Role of Limestone in Layers
Limestone provides calcium for:
Eggshell formation (~2–2.5 g Ca/egg)
Medullary bone reserves

Sustained calcium release
Particle size and solubility influence its effectiveness (Saunders-Blades *et al*., 2009).

5.4 Bioavailability of Different Inorganic Phosphate Sources

Hamdi *et al*., (2017), evaluated the comparative bioavailability of different inorganic phosphate sources, their results demonstrated that increasing dietary non-phytic phosphorus levels significantly improve feed intake, and bone mineralization, regardless of the phosphate source used. Importantly, no significant performance differences were observed between MCP, DCP, suggesting that phosphorus level is a more critical factor than the specific mineral source.

Phosphorus retention decreases as dietary phosphorus levels increase, indicating a saturation mechanism in intestinal absorption. This suggests that over-supplementation not only increases feed cost but may also reduce nutrient utilization efficiency and increase environmental phosphorus excretion (Hamdi *et al*., 2017).

These findings support the concept that optimizing dietary phosphorus levels, rather than focusing solely on phosphate source, is key to achieving both economic efficiency and optimal bird performance.

6. Integration with Phytase and Digestible Phosphorus

Phytase improves phosphorus availability by hydrolyzing phytate-bound phosphorus (Selle & Ravindran, 2007). However, high calcium diets can reduce phytase efficiency.

MCP enhances phytase response due to:

1. Higher solubility
2. Reduced Ca–phytate interaction

Thus, combining MCP with DCP improves overall phosphorus utilization.

7. Physiological Implications for Layers and Breeders

7.1 Eggshell Formation

Requires continuous calcium supply
Depends on synchronization of Ca and P availability (National Research Council, 1994)

7.2 Bone Health

Prevents osteoporosis and cage layer fatigue
Supports long production cycles (Saunders-Blades *et al.,* 2009)

7.3 Reproductive Performance

Influences hatchability
Affects embryo development
Determines chick quality

8. Strategic Evaluation of Mineral Sources

Strategy	Cost	Bioavailability	Overall Value
DCP only	Lowest	Moderate	Economical but limited
MCP only	Highest	High	Nutritionally superior
MCP + DCP	Moderate	High	Optimal balance

9. Study Limitations

The present study has several limitations that should be acknowledged:

1. Assumption of negligible basal contributions: In practical diets, ingredients such as soybean meal, corn, and other feedstuffs contribute measurable amounts of calcium and phosphorus, which would reduce the required supplemental mineral levels.
2. Static price assumptions: Ingredient prices fluctuate over time and across locations. The economic ranking of formulations may change with different price relationships between MCP and DCP.
3. Bioavailability not considered in cost calculations: The analysis treats all phosphorus as equivalent, whereas actual phosphorus availability differs among sources. An "available phosphorus" basis would provide a more accurate economic comparison.

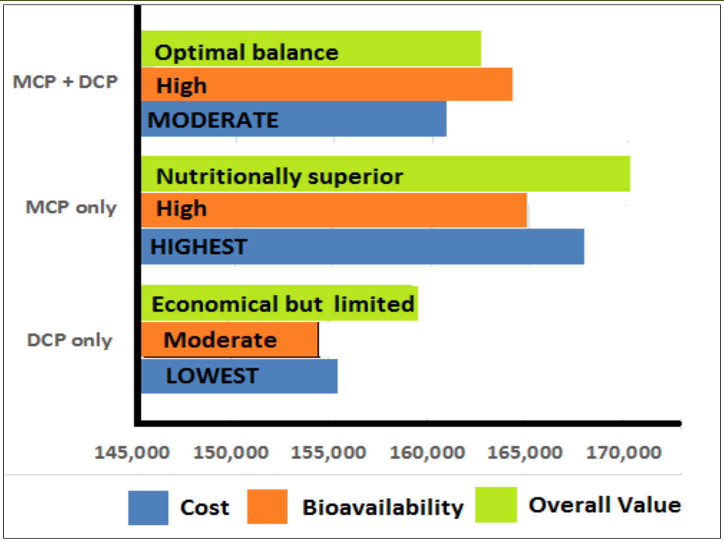

Fig. 1: Mineral sources evaluation

10. Proposed Experiment for Biological Validation

This formulation exercise evaluates mineral supplementation strategies from a nutritional and economic perspective. However, variations in phosphorus digestibility and calcium utilization may influence egg production, feed conversion efficiency, bone mineralization, and nutrient retention. Therefore, to evaluate the biological responses of broilers to diets containing different phosphate sources, controlled feeding trials are required before definitive recommendations can be made.

Design:

3 treatments 5 replicates 10–12 birds per replicate

Parameters:

Egg production Egg weight Feed intake Shell thickness Tibia ash

Feed cost per dozen eggs Statistical Model

11. Economic Perspective

From an economic perspective, the lack of significant differences in biological performance between phosphate sources suggests that feed formulation strategies can prioritize cost-effective phosphorus sources without compromising productivity. This aligns with the principle that when nutrient requirements are met, ingredient selection should be driven by cost optimization rather than perceived differences in bioavailability among similar inorganic phosphate sources.

12. CONCLUSION

The DCP-based formulation provides the lowest direct cost, while MCP-based formulations offer superior phosphorus bioavailability (Potter, 1988). The combined MCP + DCP strategy provides an optimal balance between cost and nutritional efficiency.

The small increase in mineral cost associated with MCP inclusion is minimal when expressed as a proportion of total feed cost and can be compensated by improvements in production performance, eggshell quality, and nutrient utilization.

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14. Conflict of Interest Statement

The authors declare no conflicts of interest regarding the publication of this paper.

15. Data Availability Statement

All data used in this study were derived from published literature and market price information. No new experimental datasets were generated. Data supporting the findings are available within the article.

REFERENCES

- Hamdi, M., Solà-Oriol, D., Franco-Rosselló, R., Aligué-Alemany, R., & Pérez, J. F. (2017). Comparison of how different feed phosphates affect performance, bone mineralization and phosphorus retention in broilers. *Spanish Journal of Agricultural Research*, 15(3), e0605. https://doi.org/10.5424/sjar/2017153-11149

- National Research Council. (1994). *Nutrient requirements of poultry* (9th rev. ed.). National Academy Press.
- Potter, L. M. (1988). Bioavailability of phosphorus from various phosphates based on body weight and toe ash measurements. *Poultry Science, 67*(1), 96–102. https://doi.org/10.3382/ps.0670096
- Ravindran, V., Selle, P. H., Ravindran, G., Morel, P. C. H., Kies, A. K., & Bryden, W. L. (2001). Microbial phytase improves performance, apparent metabolizable energy, and ileal amino acid digestibility of broilers fed a lysine-deficient diet. *Poultry Science, 80*(3), 338–344. https://doi.org/10.1093/ps/80.3.338
- Saunders-Blades, J. L., MacIsaac, J. L., Korver, D. R., & Anderson, D. M. (2009). The effect of calcium source and particle size on the production performance and bone quality of laying hens. *Poultry Science, 88*(2), 338–353. https://doi.org/10.3382/ps.2008-00278
- Selle, P. H., & Ravindran, V. (2007). Microbial phytase in poultry nutrition. *Animal Feed Science and Technology, 135*(1–2), 1–41. https://doi.org/10.1016/j.anifeedsci.2006.06.010