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Recent Advancements on Calcium and Phosphorus Recommendations in Broilers

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Introduction

Calcium and phosphorus have been recognized essential nutrients in chickens since 1950's (Lesson & Summers, 2001) playing important roles in bone development, among other functions. Calcium is assumed an inexpensive nutrient in animal least cost formulation while phosphorus is considered expensive and scant. The actual economic impact comes from the influence of calcium on phosphorus requirements, changes in phosphorus digestibility, buffer capacity, gut health, trace mineral absorption, fat digestibility, welfare traits, etc. Both minerals have important interactions to be considered during formulation.

Few changes have been made over the past 20 years to calcium and phosphorus recommendations because these values have supported the steady genetic improvement and also due to the complexity presented in the calcium supplementation interfering in the determination of phosphorus requirements.

Herein, the latest calcium and phosphorus recommendations for broiler at various stages of growth will be provided.

Ca and P terminology

The definition of calcium and available phosphorus and criteria used for investigating Ca and P availability are different among evaluation systems and research groups.

Table 1.-Most Common Ca and P terminology used in feed formulation

Name	Abbreviation	Description	Reference
Total Calcium	Ca	Total concentration in ingredients or complete feed	
Apparent Digestible Calcium	dCa	Precaecal digestibility: Ca in feed - Ca in the lower half of the ileum	Walk et al, 2021
Standardized Digestible Calcium	sdCa or dCa	Precaecal digestibility: Ca in feed - Ca in the lower half of the ileum + Ca endogenous losses	Walk et al, 2021
Total Phosphorus	P	Total concentration in ingredients or complete feed	
Available Phosphorus	avP	Reference Phosphate = 100 biological value. Sum = 100% P from inorganic sources + 33% P plant sources.	Shastak, and Rodehutscord, 2013
Apparent Digestible Phosphorus	dP	Precaecal digestibility = P in feed - P in the lower half of the ileum	CVB, 2018
Standardized Digestible Phosphorus	sdP or dP	Precaecal digestibility = P in feed - P in the lower half of the ileum + P in endogenous losses	David et al, 2021
Non-Phytate Phosphorus	nPP	Total concentration of P in ingredients not bound to phytin: Total P - Phytin P	Plumstead & Brake, 2007
Retainable Phosphorus	rP	Digestible but also absorbed and retained	Coon & Seo, 2007, Schothorst

The table above depicts a simplified and practical description that nutritionists use to give value to total, available, digestible and retainable phosphorus. There has been, and continues to be a great amount of research to find the best methodology but there is still variability among methods, thus different systems continue to be used around the world. However, some consensus is emerging and there is a possibility of agreeing in a method that best fits the needs of the chicken.

Because of the need of quantitative values of availability, retention and precaecal digestibility should be the preferred methods for evaluating P sources in poultry (Shastak and Rodehutscord, 2013). Conversely, in vitro and blood indicators seem unreliable.

Ca and avP responses in broilers

It is accepted that the total content of a mineral element has little significance unless its biological value to the nutrition of animals is evaluated (Peeler, 1972), therefore, many evaluation systems and groups have provided different recommendations that the poultry industry has been using. Despite being replaced by non-phytate phosphorus (NRC, 1994), the majority of broiler feeds in the USA are still formulated based on available Phosphorus. In other parts of the world, available phosphorus values are transitioning to digestible phosphorus, which is interchangeably adopted as retainable phosphorus and have lower values than available phosphorus recommendations.

Digestibility methods help to assess and understand the availability of inorganic and animal byproducts sources and covers the pitfalls of the phytate portion of plant protein ingredients. However, the use of phytase brings additional questions and assumptions in relation to phytate phosphorus released in each ingredient. Furthermore, negative correlation between dietary calcium and phytase activity has been demonstrated, and consequently it likely changes the optimal level of phosphorus in diets with and without phytase when using diets equally formulated for calcium.

Limestone is the main source of calcium in broiler diets and presumed consistent in its level of calcium (34 - 40%), which is easily analyzed. Despite the content of calcium, limestone comes in a wide range of white to dark shades and shapes (type of sedimentation). Not all limestones are made equal and this assumption has been ignored in animal nutrition for a long time. The traits related to origin and particle size and their respective solubility characteristics may determine distinctive calcium digestibility among the different limestones. Some initiatives are underway to develop a digestible calcium system as well as limestone characterization, which may be influential to achieve a precise, concise and reliable determination of calcium requirements. Thus, total calcium will continue being formulated in the near future and it will require specific adjustments according to the local conditions.

This complexity on calcium however should not discourage the nutritionists to stay in the same system. It is necessary to address the most influential points to determine the calcium and phosphorus requirements to better express the genetic potential of broilers on performance, gut health, welfare characteristics, and sustainability as following:

- Ca digestibility in limestone and phosphate reference sources.
- Determine the calcium digestibility of the main ingredients (Maize, wheat, SBM, SFM, rice bran, etc…)
- Determine the relationship of limestone Ca digestibility and solubility method.
- Determine the P requirements taking into account different DigCa : DigP ratios.
- Evaluate alternative high digestible sources of calcium to Limestone
- Optimize Ca:P ratios considering the complex dynamic of bone mineralization
- Evaluate bone health with focus on both the population instead of sampling and target body weights

Calcium and P recommendations according to different sources are presented in Table 2. Given the differences observed among them, nutritionists will be challenged to understand the intricacies of each set of studies and rationale behind each recommendation

Table 2. Latest Ca and P recommendations from various sources

	Aviagen, 2022	Cobb, 2022	CVB, 2018	Angel et al., 2021	Brazilian Tables, 2017
Starter					
Ca, %	0.95	0.96	0.88-0.92	~0.85	1.07
avP, %	0.50	0.58			0.51
dP, %			0.40	0.53	0.45
Age, d	0-10d	0-12d	0-10d		8d
BW, g	44-330	42-440		220	250
BW, g/period	330	398	195		140
FI, g/period	297	435	255		210
Grower					
	Aviagen, 2022	**Cobb, 2022**	**CVB, 2018**	**Angel et al., 2021**	**Brazilian Tables, 2017**
Ca, %	0.75	0.80	0.68-0.71	~0.78 ~0.70	0.82
avP, %	0.40	0.40			0.38
dP, %			0.31	0.39 0.31	0.35
Age, d	11-24d	13-28d	10-30d		28d
BW, g	376-1258	503-1783		650 1250	1692
BW, g/period	928	1343	1065		1552
FI, g/period	1256	1924	1715		
Finisher 1					
	Aviagen, 2022	**Cobb, 2022**	**CVB, 2018**	**Angel et al., 2018**	**Brazilian Tables, 2017**
Ca, %	0.65	0.74	0.62-0.64	0.60 0.50	0.61
avP, %	0.36	0.37			0.28
dP, %			0.28	0.25 0.23	0.26
Age, d	25-39d	29-39d	30-40d		42d
BW, g	1345-2697	1886-2954		1800 2300	3218
BW, g/period	1439	1171	730		1526
FI, g/period	2469	2091	1455		
Finisher 2					
	Aviagen, 2022	**Cobb, 2022**	**CVB, 2018**	**Angel et al., 2018**	**Brazilian Tables, 2017**
Ca, %	0.60	0.72	0.59-0.62	0.50	0.53
avP, %	0.34	0.36			0.25
dP, %			0.27	0.17	0.23
Age, d	40-51d	40-49d	40-50d		49d
BW, g	2798-3869	3062-4001		>2600	3945
BW, g/period	1172	1047	840		727
FI, g/period	2597	2299	1850		
Finisher 3					
	Aviagen, 2022	**Cobb, 2022**	**CVB, 2018**	**Angel et al., 2018**	**Brazilian Tables, 2017**
Ca, %	0.55	0.68			0.54
avP, %	0.32	0.34			0.25
dP, %					0.23
Age, d	52-market	>50d			56d
BW, g	>3869	>4099			4591

As hatched for all sources except Brazilian tables which are males (standard-high performance)

Final Considerations

The actual economic impact of calcium in broiler feeds is not the inexpensive limestone cost but its influence on phosphorus requirement, change in the feed neutrality, gut health, trace mineral absorption, fat digestibility, and welfare traits.

Studies involving limestone characterization and indirect determination of its calcium digestibility will be crucial to formulate calcium and phosphorus for broilers more accurately.

Experimental designs must considerer the effect of calcium and phosphorus on population welfare characteristics. Sampling size and method may be biased and they might subsidize improper conclusions.

The adoption of adequate calcium and phosphorus levels in broiler feeds will be relying on the development of accurate matrices for such nutrients taking into account limestone characteristics, alternative raw materials, phosphate type, or enzymes, since changes in the calcium and available phosphorus contributions are expected.

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