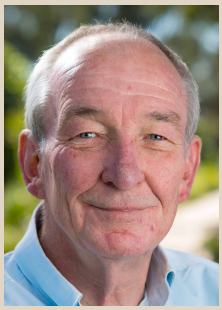
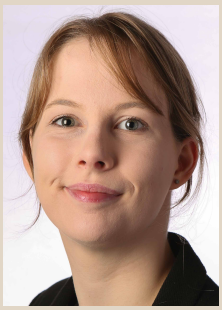
Starch-protein digestive dynamics in crude protein reduced broiler diets


Peter Selle


Peter Chrystal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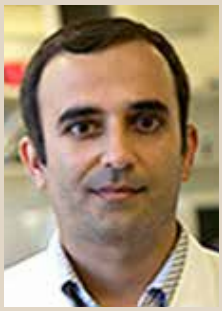
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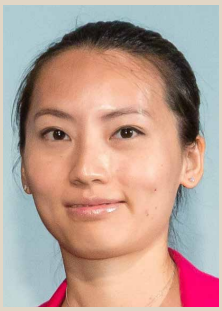
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Increasing starch-protein disappearance rate ratios are detrimental for broilers offered crude protein (CP)-reduced diets. PETER SELLE, PETER CHRTSTAL, AMY MOSS, DAFEI YIN, ALI KHODDAMI, VICTOR NARANJO and SONIA LIU* suggest limiting dietary starch levels or feed grain quantities in CP-reduced diets may permit a lower CP threshold to be achieved without compromised growth performance and increased fat deposition.

Introduction

Crude protein-reduced broiler diets have the potential to provide tangible advantages in respect of economics, bird welfare, flock health and the environment. Moderate reductions in dietary crude protein (CP) levels can be achieved without compromising broiler performance when coupled with judicious synthetic amino acid inclusions. However, there appears to be a threshold where further CP reductions negatively influence performance, especially FCR and this is associated with increased fat deposition. Starch is influential in the context of CP-reduced diets to the extent that glucose and amino acids may be competing for intestinal uptakes via their respective Na^+-dependent transport systems given atypically high dietary starch contents. There has been a considerable focus on non-essential synthetic amino acids, including glycine and serine, in the quest to lower the CP threshold. However, such specific approaches may be neglecting the importance of starch and starch-protein digestive dynamics.

Materials and methods

A total of 168 male, off-sex, Ross 308 chickens were offered maize-soy diets formulated to contain 200, 188, 172 and 156 g/kg crude protein from 14 to 35 days post-hatch (Table 1). Each dietary treatment was offered to 7 replicate cages of 6 birds per cage. Growth performance, relative abdominal fat-pad weights, apparent digestibility coefficients of starch and protein (N) in the distal jejunum were determined by standard procedures as outlined in Moss *et al*. (2018). Disappearance rates (g/bird/day) were calculated from daily feed intakes, analyzed dietary concentrations and digestibility

coefficients of starch and protein.

Results

The performance objectives for Ross 308 birds from 14 to 35 days post-hatch call for weight gains of 1,795 g/bird, feed intakes of 2,965 g/bird and an FCR of 1.652. As can be deduced from Table 2, overall weight gains (1,911 g/kg) and FCR (1.536) exceeded these objectives by 6.5% and 7.0%, respectively, in this study.

Reducing dietary crude protein did not influence weight gain; however, feed intakes were linearly increased ($p < 0.025$) as dietary CP declined. Consequently, birds offered the lowest CP diet (156 g/kg CP) had significantly higher FCR than their counterparts; for example, the transition from the 172 g/kg CP to the 156 g/kg CP diet significantly compromised FCR by 7.03% (1.629 versus 1.522; $p < 0.0001$) on the basis of a pair-wise comparison. Collectively, reducing dietary CP compromised FCR in a linear manner ($r = -0.738$; $p < 0.001$); similarly, reducing dietary CP linearly increased relative abdominal fat-pad weights ($r = -0.840$; $p < 0.001$).

Distal jejunal starch digestibility coefficients ranged from 0.909 in the 200 g/kg CP diet to 0.926 in the 156 g/kg CP diet without any significant treatment effects (data not shown). Alternatively, protein digestibility coefficients ranged from 0.674 in diet 200 g/kg CP to 0.754 in diet 156 g/kg CP with a significant linear effect ($r = -0.678$; $p < 0.001$). Starch disappearance rates in the distal jejunum increased remarkably by 41.0% from 37.8 to 53.3 g/bird/day) as CP was reduced from 200 to 156 g/kg and the linear effect was highly significant ($r = -0.933$; $p < 0.001$). In contrast, protein disappearance rates decreased modestly by 7.65% (18.3 versus 16.9 g/bird/day) but the linear effect was significant ($r = 0.382$; $p < 0.05$). As a consequence, the starch:protein disappearance rate ratio in birds offered 200 and 156 g/kg CP diets linearly increased ($r = -0.903$; $p < 0.001$) by 52.4%, from 2.08 to 3.17, respectively.

Discussion

This focus on starch and protein digestive dynamics stems from a fundamental premise that an ideal balance of glucose and amino acids should be provided at sites of skeletal muscle protein synthesis to promote efficient growth and to evade losses of surplus nutrients. That starch:protein disappearance rate ratios are indicative of weight gain and feed conversion efficiency in broiler chickens was demonstrated in a recent study where ideal disappearance rate ratios in the proximal jejunum for maximal weight gains and minimal FCR were deduced from significant quadratic regression equations.

Reductions in dietary CP are usually achieved by increasing the feed grain content at the expense of the protein meal and in the present study maize increased from 560 to 718 g/kg and soybean meal decreased from 329 to 171 g/kg when Diets 1A and 4D are compared. Consequently, analysed starch concentrations increased by 31.7% (399 versus 303 g/kg) and protein (N) decreased by 20.9% (155 versus 196 g/kg) with the transition from 200 to 156 g/kg CP diets. Therefore, it is not surprising that these quite radical modifications to the diet formulations impacted on starch-protein digestive dynamics. Importantly, in the present study, increasing starch:protein (N) disappearance rate ratios in distal jejunum quadratically influenced FCR ($r = 0.819$; $p < 0.001$) and relative abdominal fat-pad weights ($r = 0.794$; $p < 0.001$) (Figure 1). As the ratio widened feed conversion efficiency deteriorated accompanied by heavier fat-pad weights and it

Table 1: Composition of dietary treatments.

Diet Ingredient (g/kg)	200 g/kg CP	188 g/kg CP	172 g/kg CP	156 g/kg CP
Maize	560	602	659	718
Soybean meal	329	289	233	171
Vegetable oil	49.7	42.7	32.8	22.4
Lysine HCl	1.622	2.850	4.558	6.454
Methionine	2.897	3.2499	3.742	4.296
Threonine	0.974	1.533	2.311	3.178
Tryptophan	-	-	0.202	0.533
Valine	0.673	1.364	2.326	3.400
Arginine	-	0.454	2.080	3.886
Isoleucine	0.235	0.930	1.898	2.974
Leucine	-	-	-	1.239
Histidine	-	-	-	0.319
Sodium chloride	4.009	2.426	0.222	-
Sodium bicarbonate	0.010	2.401	5.730	6.187
Potassium carbonate	-	-	-	2.615
Limestone	7.25	7.17	7.06	6.93
Dicalcium phosphate	20.29	20.91	21.77	22.75
Choline chloride (60%)	0.900	0.900	0.900	0.900
Celite	20.0	20.0	20.0	20.0
Vitamin mineral premix	2.00	2.00	2.00	2.00
Analysed contents				
Starch	303	322	356	399
Protein (N x 6.25)	196	191	181	155

Table 2: Effect of dietary treatments on growth performance, relative abdominal fat-pad weights, starch and protein disappearance rates (g/bird/day) in the distal jejunum and starch:protein (N) disappearance rate ratios in broilers from 14 to 35 days post-hatch.

Treatment (g/kg CP)	Weight gain (g/bird)	Feed intake (g/bird)	FCR (g/g)	Relative fat-pad weight (g/kg)	Starch disappearance	Protein disappearance	Disappearance rate ratio
200	1,934	2,888	1.495^{a}	7.26^{c}	37.8^{a}	18.3^{ab}	2.08^{a}
188	1,931	2,896	1.500^{a}	8.49^{c}	40.4^{b}	18.9^{b}	2.14^{a}
172	1,912	2,907	1.522^{a}	10.13^{b}	45.3^{c}	18.5^{b}	2.45^{b}
156	1,864	3,036	1.629^{b}	12.40^{a}	53.3^{d}	16.9^{a}	3.17^{c}
SEM	36.31	42.25	0.0152	0.5011	0.8198	0.6333	-.0535
Significance	0.510	0.068	<0.001	<0.001	<0.001	0.043	<0.001
LSD (p <0.05)	-	-	0.0444	1.463	2.39	1.48	0.156
Linear effect	r = 0.282	r = 0.433	r = 0.738	r = 0.840	r = 0.933	r = 0.382	r = 0.908
	p = 0.146	p = 0.021	p <0.001	p <0.001	p <0.001	p = 0.045	p <0.001

is relevant that there was a positive linear relationship ($r = 0.605$; $p < 0.001$) between fat-pad weights and FCR in the present study. The quadratic equation for FCR and distal jejunal disappearance rate ratios is as follows:

$$y_{(FCR)} = 1.456 + 0.0305*ratio^2 - 0.0540*ratio$$

Conclusion

While these significant relationships are not conclusive, they do imply that quite blatant increases in digestion and absorption of starch and glucose relative to that of protein and amino acids in the context of CP-reduced diets are adversely influencing starch-protein digestive dynamics. Moreover, this imbalance is, in turn, almost certainly compromising feed conversion efficiency, which is being reflected in heavier fat-pad weights. In conclusion, this study would suggest that CP reductions in broiler diets may be better achieved by more modest feed grain increases in the formulation which would be facilitated by the partial substitution of soybean meal with feedstuffs with lesser protein contents. Limiting dietary starch levels or feed grain quantities in CP-reduced diets may permit a lower CP threshold to be realised without compromised growth performance and increased fat deposition. AP

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Figure 1 Quadratic relationships between distal jejunal starch:protein disappearance rate ratios with FCR (r = 0.838; p < 0.001) and relative abdominal fat-pad weights (r = 0.786; p < 0.001).