Revista Brasileira de Zootecnia

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.40, n.10, p.2199-2204, 2011

Crude protein level of pre-starter diets and nutritive solution for broilers

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ABSTRACT - The objective of the present study was to evaluate the effect of dietary crude protein (CP) levels and the use of a nutritive solution via drinking water on the performance of pre-starter broilers. A total of 1,224 male Avian Farm chicks, from one to 40 days of age were used. Birds were distributed in a completely randomized experimental design with a 3 × 2 × 2 factorial arrangement, consisting of three initial body weights (low: 41 g, standard: 45 g and high: 49 g; two crude protein levels at the pre-starter phase (22 and 25% CP),with or without the addition of a nutritive solution, whose nutritional level was similar to the 25% CP pre-starter diet, at a concentration of 5% of the drinking water. Each treatment included six replicates and 17 chicks per experimental unit. At the end of the pre-starter phase, all hens received a diet with 22% CP until day 21 and a diet with 20% CP from the 21st to the 40th day. The use of the pre-starter diet with higher nutritional levels and the nutritive solution enhanced broiler performance. The early nutrient supply via drinking water resulted in better broiler performance and uniformity. However, birds with low initial body weight continued to present lower body weight at market age.

Key Words: broilers, chicks, nutritional requirements, performance, starting phase

Introduction

The first two weeks of life of broilers correspond to about 17% of their rearing period in days, and 8 to 10% as a percentage to final weight gain (Lilburn, 1998). This is the period of fastest bone, muscle and immune system development. When broiler growth is compromised, with consequent weight loss soon after hatching, performance is impaired until slaughter (Vieira & Moran, 1998 b,c; Vieira & Pophal, 2000).

Some authors have shown the need to supply water and feed immediately after hatching (Tarvid, 1992; Maiorka et al., 2003; Gonzales et al., 2008). Noy & Pinchasov (1993) and Noy & Sklan (1998; 1999) observed that chicks receiving both solid and liquid feed at the hatchery presented better performance at slaughter as compared with those fasting until housing. Penz Junior (1992), using calculations based on metabolic weight units, that the nutritional requirements during the first week of life are higher than on the following weeks.

Another factor that should be considered at the starting phase of broiler rearing is initial weight, considering that breeder age influences broiler weight. As breeders age, they produce larger follicles, resulting in eggs with larger yolks, which represent a higher proportion of total egg weight; and consequently hatch heavier chicks (Vieira, 2000). Each extra gram in hatchling weight is equivalent, in average, to 9 additional grams at slaughter (Stringhini et al., 2003).

Considering that the two first weeks of life determine broiler performance at slaughter, the present study aimed at evaluating the effect of hatching weight of broiler chicks fed pre-starter diets with two different protein levels associated or not to the addition of a nutritive solution in the drinking water during the first days of life on broiler performance at slaughter.

Material and Methods

In this experiment, 1,224 male Avian Farm chicks, derived from 40- to 44-week-old broiler breeders, were studied during the period of 1 to 40 days of age. Birds were distributed according to a completely randomized experimental design in a 3 × 2 × 2 factorial arrangement, consisting of three initial weight averages (light, 41 g; intermediate, 45 g; and heavy, 49 g), two protein levels in the pre-starter diet (22 and 25% CP) and the addition or not of a nutritive solution to the drinking water, totaling 12 treatments with six replicates of 17 experimental units each.

Received May 26, 2009 and accepted March 11, 2011.
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Chicks were individually weighed at the hatchery and separated according to the three weight ranges, transported to the experimental house and distributed in the experimental pens. The time interval between hatching and the supply of water or water with the nutritive solution was 8 h, and for feed supply, it was 10 h.

The pre-starter diets containing 22 and 25% crude protein (CP) were supplied at a pre-determined amount of 300 g. Subsequently, a starter diet with 22% CP was supplied to all birds until 21 days of age, and a grower diet with 20% CP from 22 to 40 days. Diets were formulated according to Rostagno et al. (2005) (Table 1).

Table 1 - Ingredients and calculated compositions of the experimental diets

Ingredient (%)	Pre-starter 1-7 days		Starter 8-21 days	Grower 22-40 days
	25%	22%		
Corn	48.394	56.552	56.552	59.363
Soybean meal 46%	41.669	37.203	37.203	33.415
Corn gluten meal 60%	3.000	—	—	—
Soybean oil	3.194	2.416	2.416	3.760
Limestone	1.003	0.979	0.979	0.921
Dicalcium phosphate	1.878	1.806	1.806	1.595
Salt	0.454	0.452	0.452	0.400
*Premix (vitamins + minerals)	0.263	0.263	0.263	0.263
DL-methionine 99%	0.144	0.218	0.218	0.183
L-lysine HCl 79%	0.001	0.111	0.111	0.100
Calculated composition				
Metabolizable energy, kcal/kg	2.975	2.975	2.975	3.100
Crude protein, %	25.000	22.000	22.000	20.487
Calcium, %	1.000	0.960	0.960	0.874
Available phosphorus, %	0.470	0.450	0.450	0.406
Sodium, %	0.224	0.222	0.222	0.199
Total lysine, %	1.310	1.263	1.263	1.156
Digestible lysine, %	1.180	1.143	1.143	1.045
Total methionine + cystine, %	0.926	0.897	0.897	0.825
Digestible methionine + cystine, %	0.836	0.816	0.816	0.748

*Vit. A - 10,000 IU; vit. D3 - 2,000 IU; vit. E - 30 IU; vit. B1 - 2 mg; vit. B6 - 3 mg; vit. B12 - 0.015 mg; pantothenic acid - 12 mg; biotin - 0.10 mg; vit. K3 - 3 mg; folic acid - 1.0 mg; nicotinic acid - 50 mg; choline chloride 60% - 100 g; antioxidant - 1.0 mg (BHT); selenium - 0.25 mg; salinomycin - 66 mg; virginiamycin - 10 mg; manganese - 106 mg; iron - 100 mg; copper - 20 mg; cobalt - 2 mg; iodine - 2 mg; zinc - 50 mg.

The nutritive solution, formulated with high metabolizable energy content and nutritional levels similar to those of the pre-starter diet with 25% CP, consisted of high solubility ingredients, and did not contain any antibiotic growth promoters or coccidiostats (Table 2). It was supplied at a concentration of 5% twice a day in screw pressure drinkers for the first seven days of the broilers' life. After each time the solution was supplied, the leftovers were placed in containers, and subsequently oven-dried in order to calculate consumption.

Birds and feed leftovers were weighed on days 7, 14, 21 and 40 in order to determine weight gain, feed intake and feed conversion ratio. Mortality was also recorded. Birds were individually weighed in order to determine the standard error of the mean body weight on days 21 and 40.

At the end of the first week, nutritive solution leftovers were weighed and oven-dried (60 ºC) to calculate consumption.

Analyses of variance and comparison of the means were performed using SAEG statistical package.

Table 2 - Ingredient composition of the nutritive solution

Ingredient (%)	Nutritive solution (0.05 g/L water)
Micronized soybeans	44.910
Sugar	36.765
Soybean protein isolate	10.000
Powdered skimmed milk	3.600
Betatricalcium phosphate	1.890
Calcium hydroxide	0.495
DL-methionine 99%	0.468
* Premix (vitamins + minerals)	0.540
Fumaric acid	0.450
L-lysine HCl 79%	0.117
Salt	0.270
L-threonine	0.045
Sodium bicarbonate	0.450
Calculated composition	
Metabolizable energy, kcal/kg	3.743
Crude protein, %	25.342
Calcium, %	0.884
Available phosphorus, %	0.441
Sodium, %	0.274
Total lysine, %	1.667
Digestible lysine, %	1.167
Methionine + total cystine, %	1.182
Methionine + digestible cystine, %	0.953

*Vit. A - 10,000 IU; vit. D3 - 2,000 IU; vit. E - 30 IU; vit. B1 - 2 mg; vit. B6 - 3 mg; vit. B12 - 0.015 mg; pantothenic acid - 12 mg; biotin - 0.10 mg; vit. K3 - 3 mg; folic acid - 1.0 mg; nicotinic acid - 50 mg; choline chloride 60% - 100 g; antioxidant - 1.0 mg (BHT); selenium - 0.25 mg; salinomycin - 66 mg; virginiamycin - 10 mg; manganese - 106 mg; iron - 100 mg; copper - 20 mg; cobalt - 2 mg; iodine - 2 mg; zinc - 50 mg.

Results and Discussion

During the entire experimental period, mortality rate was 0.96% and was not influenced (P>0.05) by the evaluated factors. During the period of 1 to 7 days, there was no interactions between the factors, but there were significant effects (P<0.05) of initial weight, dietary CP level and nutritive solution utilization on weight gain, feed intake and feed conversion ratio, except for feed intake, which was not influenced by dietary CP level (Table 3).

Broilers with low initial weight presented lower weight gain, while there was no statistical difference (P>0.05) in the weight gain of birds with intermediate and high initial weight. Stringhini et al. (2003) and Lara et al. (2005) also observed higher body weight in broilers with high initial weight as compared with intermediate and low initial weight at 7 days of age. The pre-starter diet with 25% CP promoted higher weight gain and better feed conversion ratio. This was also observed by Everaert et al. (2010). The addition of the nutritive solution to the drinking water also resulted in higher weight gain (10 g, in average) relative to those that received only water, regardless of initial weight and protein levels in the pre-starter diet. Nutritive solution dry matter intake was 14 ± 0.7 g per bird during the period of 1 to 7 days, corresponding to 0.054 kcal/kg EM, 0.39 g crude protein and 0.018 g digestible lysine.

During the period of 1 to 14 days, weight gain was significantly influenced (P<0.05) by digestible lysine dietary levels (Table 4).

Weight gain was higher (P<0.05) in broilers with high initial weight. Birds fed on the nutritive solution in the drinking water presented higher weight gain, regardless of the protein level of the pre-starter diet, and those with intermediate and heavy initial weights had higher feed intake (P<0.05) than those with light initial weight.

Table 3 - Effects of crude protein (CP) level in the pre-starter diet and of the nutritive solution on feed intake, weight gain and feed conversion ratio of 1- to 7-day-old broilers

	Feed intake (g)					Weight gain (g)					Feed conversion ratio (g/g)				
	Crude protein level (%)					Crude protein level (%)					Crude protein level (%)				
	22		25			22		25			22		25		
Initial weight	Nutritive solution				Mean	Nutritive solution				Mean	Nutritive solution				Mean
	-	+	-	+		-	+	-	+		-	+	-	+	
Low	125	131	131	132	130B	70	81	78	81	78B	1.785	1.617	1.679	1.629	1.666AB
Intermediate	139	151	140	148	145A	79	89	87	96	88A	1.759	1.697	1.609	1.542	1.648B
High	134	145	142	143	141A	82	94	86	98	90A	1.634	1.542	1.651	1.459	1.567A
Mean crude protein[1]	138		139			83b		88a			1.663b		1.579a		
Mean nutritive solution[2]	135b			142a		80b			90a		1.687b			1.577a	
CV (%)	6.57					7.28					6.79				

[ab] Means followed by different lowercase letters in the same row are different by the F-test (P<0.05).
[AB] Means followed by different capital letters in the same column are different by SNK test (P<0.05).
[1] Mean data relative to the CP level of the pre-starter diet.
[2] Mean data relative to the nutritive solution.

Table 4 - Effects of crude protein (CP) level in the pre-starter diet and of the nutritive solution on feed intake, weight gain and feed conversion ratio of 1- to 14-day-old broilers

	Feed intake (g)					Weight gain (g)					Feed conversion ratio (g/g)				
	Crude protein level (%)					Crude protein level (%)					Crude protein level (%)				
	22		25			22		25			22		25		
Initial weight	Nutritive solution				Mean	Nutritive solution				Mean	Nutritive solution				Mean
	-	+	-	+		-	+	-	+		-	+	-	+	
Low	396	419	422	426	416B	1.616	1.563	1.568	1.434	1.540	1.616	1.563	1.568	1.434	1.540
Intermediate	431	438	444	473	447A	1.645	1.510	1.510	1.551	1.552	1.645	1.510	1.510	1.551	1.552
High	441	451	446	464	451A	1.500	1.498	1.517	1.497	1.503	1.500	1.498	1.517	1.497	1.503
Mean crude protein[1]	429		446			277b		295a			1.548		1.512		
Mean nutritive solution[2]	430			445		276b			295a		1.558		1.508		
CV (%)	8.10					6.60					6.56				

[ab] Means followed by different lowercase letters in the same row are different by the F-test (P<0.05).
[AB] Means followed by different capital letters in the same column are different by SNK test (P<0.05).
[1] Mean data relative to the CP level of the pre-starter diet.
[2] Mean data relative to the nutritive solution.

During the period of 1 to 21 days, there was a significant interaction ($P<0.05$) between average initial weight and crude protein level of the pre-starter diet for weight gain, feed intake and feed conversion ratio (Table 5).

Heavy hens fed the pre-starter diet containing 25% CP presented higher weight gain and better feed conversion ratio. They also had higher intake, regardless of CP level in the pre-starter diet.

Weight gain was 36 g higher in broilers fed on the pre-starter diet with 25% CP as compared with those fed on the pre-starter diet with lower protein level, of 22% CP, regardless of average initial weight; which disagrees with the findings of Rocha et al. (2003), who did not observe any effect ($P>0.05$) of crude protein levels in the pre-starter diet on the weight gain of 21-day-old broilers. Silva et al. (2007) also did not find any statistical difference ($P>0.05$) at 21 days between broilers fed on pre-starter diets containing 21.9 or 23% crude protein.

Birds that received the nutritive solution until 7 days of age presented higher weight gain and feed intake on day 21, regardless of initial weight, possibly because the supply of nutrient via nutritive solution stimulated the rapid development of the digestive system of the birds, as observed by Noy & Sklan (1998; 1999); however, feed conversion ratio was not affected ($P>0.05$) on day 21.

During the total experimental period of 1 to 40 days, weight gain was influenced ($P<0.05$) by the crude protein levels of the pre-starter diet, by broiler initial weight and by the supply of the nutritive solution (Table 6).

Birds fed the on pre-starter diet with 25% crude protein presented higher weight gain ($P<0.05$); however, there were no differences ($P>0.05$) in feed intake or feed conversion ratio. Broilers fed on the nutritive solution during the first weeks of life maintained higher weight gain and feed intake on day 40 ($P<0.05$), but presented no difference ($P>0.05$) in feed conversion ratio as compared with those that received only water.

The higher initial weight determined higher weight gain ($P<0.05$), as demonstrated by the fact that the birds heavier at hatch presented higher weight gain as compared with those with intermediate initial weight, which also had statistically higher weight gain ($P<0.05$) than the broilers with low initial weight, as measured on day 40. Stringhini et al. (2003), working with broilers with intermediate and high initial weight did not observe any statistical differences ($P>0.05$) in body weight 42 days, but in the same period, the heavy broilers at hatch presented body weight 104 g higher than the light broilers. Lara et al. (2005) observed that heavier broilers at housing presented higher body weight ($P<0.05$) at 43 days, whereas no difference was observed ($P>0.05$) between birds with intermediate and low initial weight.

There was a significant interaction ($P<0.05$) between initial weight and dietary crude protein level in the pre-starter diet for a feed conversion ratio. Light and heavy broilers fed on the pre-starter diet with 25% CP presented better feed conversion ratio.

At 21 and 40 days of age, all birds were individually weighed in order to calculate the mean standard deviation of body weight in each treatment (Table 7), but no significant differences were detected ($P>0.05$). However, on day 40, birds receiving the nutritive solution via drinking water during the first week presented 13.74% lower mean standard

Table 5 - Effects of crude protein (CP) level in the pre-starter diet and of the nutritive solution on feed intake, weight gain and feed conversion ratio of 1- to 21-day-old broilers

	Feed intake (g)					Weight gain (g)					Feed conversion ratio (g/g)				
	Crude protein level (%)					Crude protein level (%)					Crude protein level (%)				
	22		25			22		25			22		25		
Initial weight	Nutritive solution				Mean	Nutritive solution				Mean	Nutritive solution				Mean
	-	+	-	+		-	+	-	+		-	+	-	+	
Low	948	975	1032	1056	1003	604	625	660	691	645	1.570	1.561	1.563	1.529	1.556
	(962)Yz		(1044)Xx			(615)Yy		(676)Xy			(1.566)Yz		(1.550)Yz		
Intermediate	978	1037	1047	1056	1030	663	671	679	695	677	1.475	1.545	1.542	1.518	1.521
	(1008)Yy		(1052)Xx			(667)Yx		(687)Xy			(1.510)Yx		(1.530)Yy		
High	1034	1048	1017	1056	1039	671	683	694	714	691	1.540	1.534	1.464	1.480	1.505
	(1041)Xx		(1037)Xx			(677)Yx		(704)Xx			(1.537)Yy		(1.472)Xx		
Mean crude protein[1]	1003		1044			653		689			1.538		1.516		
Mean nutritive solution[2]	1009b			1038a		662b			680a		1.526			1.528	
CV (%)		3.64					2.62					3.07			

[ab] Means followed by different lowercase letters in the same row are different by the F-test ($P<0.05$).
[XY] Means followed by different capital letters in the same row are different by SNK test ($P<0.05$). Initial weight × crude protein level interaction.
[xy] Means followed by different lowercase letters in the same columns are different by SNK test ($P<0.05$). Initial weight × crude protein level interaction.
[1] Mean data relative to the CP level of the pre-starter diet.
[2] Mean data relative to the nutritive solution.

deviation as compared with those not fed on the nutritive solution during that period. This indicates higher body weight uniformity, and consequently, better processing yield.

The results of the present study demonstrate that broilers have higher nutritional requirements in the first week of age, as observed by Penz Junior (1992), Rocha et al. (2003), Stringhini et al. (2006) and Silva et al. (2007), who recommend the use of pre-starter diets with higher nutritional levels.

According to Okada (1994), every gram dropped in body weight at housing represents 10 to 15 g lower body weight at slaughter. In the present experiment, the difference in weight gain between broilers with a low (41 g) and high (49 g) initial weight was 109 g at 40 days of age, that is, each gram less in body weight at housing represented 13 g lower body weight at slaughter. This result is consistent with the findings of Wilson (1991), Pinchasov (1991), Vieira & Moran Junior (1998 abc) and Stringhini et al. (2003), who observed that each gram less in body weight at housing corresponded to 9.4 g less at slaughter.

The nutritive solution was used to supply nutrients as soon as possible to the broilers, as the development of the gastrointestinal tract of broilers is directly related to the presence of substrate (Austic, 1985; Noy & Sklan, 1997; Penz Junior & Vieira, 1998; Sklan, 2000).

Noy & Sklan (1998; 1999), working with broiler chicks, supplied liquid, semi-solid and solid nutrient and water, individually or combined, post-hatch, whereas another group fasted. They also observed higher weight gain in the broilers that received early feeding, but no differences in feed conversion ratio. The improvement in weight gain was gradual until 21 days and was maintained up to slaughter.

Table 6 - Effects of crude protein (CP) level in the pre-starter diet and of the nutritive solution on feed intake, weight gain and feed conversion ratio of 1- to 40day-old broilers

	Feed intake (g)					Weight gain (g)					Feed conversion ratio (g/g)				
	Crude protein level (%)					Crude protein level (%)					Crude protein level (%)				
	22		25			22		25			22		25		
Initial weight	Nutritive solution				Mean	Nutritive solution				Mean	Nutritive solution				Mean
	-	+	-	+		-	+	-	+		-	+	-	+	
Low	3636	3679	3690	3702	3677B	2069	2098	2143	2185	2124C	1.757	1.754	1.722	1.694	1.731
											(1.756)Yy		(1.708)Xx		
Intermediate	3655	3837	3875	3853	3805A	2143	2182	2191	2217	2183B	1.706	1.758	1.769	1.738	1.743
											(1.732)Yy		(1.754)Yy		
High	3831	3841	3766	3908	3837A	2199	2216	2239	2278	2233A	1.742	1.733	1.682	1.716	1.718
											(1.738)Yy		(1.699)Xx		
Mean crude protein[1]	3747		3799			2152b		2209a			1.742		1.720		
Mean nutritive solution[2]	3742b			3803a		2164b			2196a		1.730			1.732	
CV (%)	3.17					2.09					2.11				

[ab] Means followed by different lowercase letters in the same row are different by the F-test (P<0.05).
[AB] Means followed by different capital letters in the same column are different by SNK test (P<0.05).
[XY] Means followed by different capital letters in the same row are different by SNK test (P<0.05). Initial weight × crude protein level interaction.
[xy] Means followed by different lowercase letters in the same columns are different by SNK test (P<0.05). Initial weight × crude protein level interaction.
[1] Mean data relative to the CP level of the pre-starter diet.
[2] Mean data relative to the nutritive solution.

Table 7 - Effect of crude protein (CP) level in the pre-starter diet and of the nutritive solution (NS) on the mean standard deviation of broiler body weight on days 21 and 40

	Standard deviation d 21					Standard deviation d 40				
	Crude protein level (%)					Crude protein level (%)				
	22		25			22		25		
Initial weight	Nutritive solution				Mean	Nutritive solution				Mean
	-	+	-	+		-	+	-	+	
Low	113.99	93.74	93.56	94.80	99.02	343.30	159.32	226.22	178.60	199.61
Intermediate	90.93	88.56	82.19	93.76	88.86	200.01	193.51	249.52	220.09	190.78
High	103.60	97.30	93.62	90.97	96.37	193.94	188.26	218.34	208.60	202.29
Mean crude protein[1]	98.02		91.48			196.39		216.90		
Mean nutritive solution[2]	96.32			93.19		221.89			191.40	
CV (%)	23.43					25.70				

[1] Mean data relative to the CP level of the pre-starter diet.
[2] Mean data relative to the nutritive solution.

The nutritive solution did not present any fermentation; however, low solubility was observed, as in a few minutes, the solution decanted, which contributed for the nutritive solution intake of only 14 g per bird during the first week, in addition to making drinker management difficult. It was experimentally demonstrated that the early supply of nutrients via drinking water improves broiler performance, but further studies are needed to make this type of feeding feasible in large commercial broiler farms.

Conclusions

The use of a pre-starter diet with high nutritional levels and the early supply of nutrients via drinking water improve broiler performance. Low initial body weight of broilers at housing negatively influences body weight at slaughter.

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