Varying protein and amino acid profiles with changing ballast protein concentration in diets for male broilers

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Abstract

An experiment was conducted to investigate the responses of male broiler chicks to graded dietary amino acid (AA) levels with changing ballast protein concentrations. Ballast protein concentrations were varied by reducing the level of indigestible AA and the level of potentially excess digestible amino acids. Broiler performance improved due to reduced indigestible AA levels in the diet. This confirms that indigestible AA can limit broiler performance. Reducing the potentially excess digestible AA level by omitting the non-essential AA and essential AA, except Lys, Met+Cys, Thr and Trp, in the diet formulation, resulted in impaired broiler performance. This suggests that the requirement of broiler chickens for non-essential AA and specific essential AA is higher than the basal level employed in the present experiment.

Introduction

Recent work of Wijtten et al. (2004a) showed that increasing levels of balanced amino acid (AA) profiles (ideal protein, IP) improved weight gain and feed conversion efficiency up to higher AA levels than recommended in literature. However, the increase of dietary IP levels was inevitably associated with an increased level of dietary ballast protein in the form of indigestible AA and potentially excess digestible AA. Indigestible AA are subject to proteolytic fermentation in the distal part of the intestine. This can result in the formation of potentially toxic compounds such as amines, ammonia, volatile phenols and indoles (Williams et al., 2001). Excess digestible AA are absorbed by the bird and subsequently oxidised. Birds excrete the ammonia originating from the proteolytic fermentation of indigestible AA and the nitrogen originating from the oxidation of excess digestible AA in the form of urea, requiring additional energy. Increased dietary indigestible protein levels have been shown to deteriorate weight gain and feed conversion ratio (FCR) in broiler chickens (De Lange et al., 2003). Hence, in previous experiments with increased IP levels, negative effects of ballast protein might have prevented broilers from showing maximum responses in performance. The present study was conducted to investigate the responses of male broiler chicks to graded dietary AA levels with changing ballast protein concentrations. An additional objective was to confirm that the effects of protein and AA demonstrated by Wijtten et al. (2004a) and Wijtten et al. (2004b) are independent of secondary raw material effects.

Materials and Methods

A total of 1440 male Ross 308 broilers was allocated to twelve dietary treatments. Each treatment consisted of six replicate battery cages of 20 birds. Water and pelleted feed were available for *ad libitum* consumption. The experiment was carried out from 14 to 35 days of age and carcass data were collected at day 36 of age. In a 3 x 4 factorial arrangement, broilers were fed diets (Table 1) with three apparent faecal digestible (AFD) AA levels (100, 110 and 120% of CVB recommendations (Schutte, 1996) and 4 ballast protein concentrations (entire ideal protein (Entire IP), essential AA plus non-essential AA (EAA+NEAA), essential AA (EAA) and first limiting AA (FLAA). All diets were isocaloric. Identical ratios were used between all AA considered in the formulations with different ballast protein concentrations.

Table 1: Calculated analysis (g/kg) of experimental diets with 100 and 120% of CVB recommendations (Schutte, 1996).

Ballast protein	Entire IP			EAA+NEAA		EAA		FLAA	
AA (% CVB)	90*	100	120	100	120	100	120	100	120
Sum of AA	181	201	240	198	233	190	208	183	188
AFD Lys	9.2	10.2	12.2	10.2	12.2	10.2	12.2	10.2	12.2
AFD Met+Cys	6.9	7.7	9.2	7.7	9.2	7.7	9.2	7.7	9.2
AFD Thr	5.8	6.5	7.7	6.5	7.7	6.5	7.7	6.5	7.7
AFD Trp	1.9	2.1	2.5	2.1	2.5	2.1	2.5	2.1	2.5
AFD Ile	6.9	7.7	9.2	7.7	9.2	7.7	9.2	6.9	6.9
AFD Arg	10.3	11.4	13.7	11.4	13.7	11.4	13.7	10.3	10.3
AFD Phe	8.5	9.4	11.3	9.4	11.3	9.4	11.3	8.5	8.5
AFD His	3.9	4.4	5.2	4.4	5.2	4.4	5.2	3.9	3.9
AFD Leu	14.0	15.6	18.7	15.6	18.7	15.6	18.7	14.0	14.0
AFD Tyr	6.0	6.7	8.0	6.7	8.0	6.7	8.0	6.0	6.0
AFD Val	7.4	8.3	9.9	8.3	9.9	8.3	9.9	7.4	7.4
Indigestible AA	23.5	25.9	30.9	23.5	23.5	23.5	23.5	23.5	23.5
AFD NEAA	76.3	84.9	101.8	84.9	101.8	76.3	76.3	76.3	76.3

*Basal diet, not fed to the birds.

AFD AA levels were increased from a basal diet with 90% of CVB recommendations. In the “Entire IP” diets, AFD AA levels were increased with raw materials and crystalline Lys and Met in accordance with the method reported by Wijtten et al. (2004b). In the “EAA+NEAA” diets, AFD AA levels were increased up to identical levels of the three “Entire IP” diets exclusively using crystalline AA. Whilst the levels of essential AA were increased with the individual crystalline AA, the sum of non-essential AA was covered by the inclusion of crystalline Glu. Crystalline Gly covered the sum of Gly and Ser. Levels of essential AFD AA in the “EAA” diets were increased up to identical levels of the “Entire IP” diets using crystalline essential AA. In the “FLA” diets, only Lys, Met+Cys, Thr and Trp were increased up to identical AFD AA levels of the “Entire IP” diets. The “Entire IP” diets had the highest ballast protein concentration in the form of both indigestible AA and excess digestible AA. Crystalline AA were considered 100% digestible. Therefore, the indigestible AA content of the “EAA+NEAA” diets was reduced compared to the “Entire IP” diets. Reducing the level of non-essential AA reduced the sum of AA in the “EAA” diets. Speculating that non-essential AFD AA are offered in excess in the “Entire IP” and “EAA+NEAA” diets, the “EAA” diets had a further reduced ballast protein concentration. In the “FLAA” diets, part of the essential AA was not included, which means a further reduction of the overall AFD AA content. The “FLAA” diets, with only the commercially available crystalline AA included, were used to examine to what extent the responses obtained with “EAA+NEAA” and “EAA” diets could be realised under conditions that can be implemented in practice under the current legislation.

Results and Discussion

The analysed CP and AA levels of the experimental diets confirmed calculated values. During the experiment, health status of the birds was poor due to respiratory disease (Infectious Bronchitis) and average bird performance was clearly impaired compared to previous experiments in the same research centre. Therefore, the present findings might be different from results that would have been obtained with a healthy flock of broiler chickens. Best performance was obtained with “EAA+NEAA” diets, followed by “Entire IP”, “EAA” and “FLAA” diets (Table 2). Increasing AA levels improved weight gain and FCR in “EAA+NEAA” diets. Weight gain improved numerically and FCR significantly due to increased AA levels in “Entire IP” diets.

Table 2: Effect of graded AA levels (expressed as % of CVB recommendation) in diets with changing ballast protein concentration (BP) on body weight gain (BWG, g) and FCR (0-35 days of age) and breast meat (BMY, % of carcass) and abdominal fat yield (AFY, % of carcass) (day 36 of age) in male broilers.

BP	Entire IP			EAA+NEAA			EAA			FLAA		
AA	100	110	120	100	110	120	100	110	120	100	110	120
BWG	1686^{cde}	1737^{abc}	1736^{abc}	1709^{cde}	1794^{a}	1771^{ab}	1687^{cde}	1713^{bcd}	1675^{def}	1679^{cdef}	1651^{ef}	1625^{f}
FCR	1.63^{de}	1.60^{ef}	1.58^{fg}	1.63^{e}	1.54^{g}	1.55^{g}	1.67^{b}	1.61^{ef}	1.63^{cde}	1.67^{bcd}	1.67^{bc}	1.71^{a}
BMY	31.8^{cd}	32.4^{bc}	33.0^{ab}	32.2^{c}	33.1^{a}	33.1^{a}	31.4^{de}	31.8^{cd}	31.0^{e}	31.0^{e}	31.0^{e}	30.9^{e}
AFY	2.14^{cde}	1.90^{e}	1.47^{f}	2.40^{abc}	2.08^{de}	1.90^{e}	2.36^{bc}	2.27^{bcd}	2.33^{bcd}	2.64^{a}	2.50^{ab}	2.65^{a}

[a,b,c,d,e,f] Means within a row with different superscripts differ significantly ($P<0.05$).

The birds hardly showed a response in weight gain due to increased AA levels in "EAA" diets, whilst FCR improved. Increasing AA levels in "FLAA" diets resulted in a numerically decreased weight gain and significantly impaired FCR. Breast meat yield increased and abdominal fat deposition decreased due to increasing AA levels in "Entire IP" and "EAA+NEAA" diets, whereas in "EAA" and "FLAA" breast and abdominal fat yield were hardly affected. The above effects resulted in interactions of AA level and ballast protein concentration for FCR (P=0.002), breast yield (P=0.018) and abdominal fat deposition (P=0.007). The response to an increased AA level in "Entire IP" diets was in accordance with earlier work (Wijtten et al, 2004a, Wijtten et al., 2004b). The fact that the responses to increased AA levels in "EAA+NEAA" and "Entire IP" diets were similar, provides evidence that the effects of protein and AA reported by Wijtten et al. (2004a) and Wijtten et al. (2004b) are independent of raw material effects. Performance of birds fed "EAA+NEAA" diets was significantly improved compared to "Entire IP" diets, which supports the hypothesis that indigestible amino acids can reduce performance. The impaired performance of broilers fed "EAA" versus "EAA+NEAA" diets suggests that next to a requirement for essential AA, also a requirement for non-essential amino acids exists. The negative response of broilers to "FLAA" might be caused by severe imbalances in the amino acid profile.

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