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COMPARISON BETWEEN "THEORETICAL" AND "MEASURED" VALUES OF TRUE DIGESTIBILITY OF PROTEIN AND AMINO ACIDS OF DIETS IN COCKERELS

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ABSTRACT

The effect of different mixtures of 4 feedstuffs (corn, soybean meal, dehulled and whole rapeseed meals) in the diets on *theoretical* and *measured* values of true digestibility of protein (TDP) and amino acids (TDAA) were investigated in adult cockerels. Six experimental diets were formulated. Diet 1, 2, 3 and 4 contained 15, 17, 19 and 22% of crude protein (CP), respectively. Diets 5 and 6 were as diets 4 and 1 respectively but were diluted with starch so as to obtain a CP content of about 11%. These last diets were formulated in order to study the effect of protein dilution on TDP and TDAA when the same feedstuffs were used in the diet. In order to obtain the *measured* values of TDP and TDAA, thirty-six adult cockerels (Isa Brown) were fasted for 24 hours and then forced-fed with a moistened diet composed of 50% water and 50% feed. The *theoretical* values were calculated from the individual digestibility value of each feedstuff tested. The result of the current experiment indicated that there was no significant difference ($P > 0.05$) between *theoretical* and *measured* values for TDP in the six diets tested. However, there were significant differences ($P < 0.01$) between *theoretical* and *measured* values of TDAA where *measured* < *theoretical* for the major part of amino acids. Protein dilution had no significant effect on TDP and TDAA values.

(Key Words: True Amino Acid Digestibility, Feed Ingredients, Cockerels, Wet Force-Feeding Method, Ingredient Mixtures.)

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NILAI KECERNAAN RIIL PROTEIN DAN ASAM AMINO YANG DIDAPAT SECARA TEORI DAN TERUKUR PADA RANSUM AYAM JANTAN DEWASA

INTISARI

Penelitian bertujuan untuk mengetahui pengaruh campuran empat bahan pakan (jagung, bungkil kedelai dan dua macam bungkil *rapeseed*) di dalam ransum terhadap nilai kecernaan riil protein (TDP) dan asam amino (TDAA) yang didapat secara teori dan terukur pada ayam jantan dewasa. Empat ransum penelitian yang digunakan adalah ransum 1, 2 3, dan 4 yang mengandung berturut-turut 15, 17, 19 dan 22% protein kasar, sedangkan ransum 5 dan 6 dibuat dari ransum 4 dan 1 yang telah dicampur dengan pati sehingga kandungan protein kasarnya menjadi 11%. Kedua ransum yang terakhir ini digunakan untuk mengetahui pengaruh penurunan kadar protein ransum terhadap nilai TDP dan TDAA apabila menggunakan bahan pakan yang sama. Untuk mendapatkan nilai TDP dan TDAA yang terukur, tiga puluh enam ekor ayam jantan dewasa strain *Isa Brown* dipuasakan selama 24 jam, dan kemudian diloloh dengan menggunakan metode pelololhan basah (campuran 50% air dan 50% pakan). Untuk TDP dan TDAA teori didapat dari kalkulasi dari nilai kecernaan individu masing-masing bahan pakan yang digunakan. Hasil penelitian menunjukkan bahwa terdapat perbedaan yang tidak nyata antara nilai TDP teori dan yang terukur untuk 6 macam ransum perlakuan. Nilai TDAA terukur lebih kecil ($P<0,01$) dibanding nilai TDAA teori untuk sebagian besar asam amino. Kadar protein ransum berpengaruh tidak nyata terhadap nilai TDP dan TDAA ayam jantan dewasa.

(Kata Kunci: Nilai Kecernaan Riil Asam Amino, Bahan Pakan, Ayam Jantan Dewasa, Metode Pelolohan Basah.)

Introduction

True digestibility of proten (TDP) and amino acid (TDAA) values of feedstuffs used for diet in poultry feeding are, frequently, obtained from the experiments using a single raw material in cockerels. However, in practice, diets were generally made from combinations of two or more feedstuffs. The effects of mixture of some feedstuffs in diets on true metabolizable energy (TME) and true digestibility of amino acids (TDAA) in poultry were reported by Dale and Fuller (1980) and Engster et al. (1985), respectively. In both experiments above, the dry force-feeding method of Sibbald (1976) was used. However, the validity of this latter method may be questioned, as amino acid digestibility may be influenced by the quantity and type of feed consumed (Nordheim and Coon, 1984). Wehner and Harrold (1982) showed, moreover, that the dry force-feeding of Sibbald (1976) produced more stress, as shown by the post-feeding behaviour, than the moist force-feeding (slurry) method.

A new moist force-feeding method was described by Lessire (1990) to measure the TME values in feedstuffs. This rapid method (moist force-feeding) gives values which are in good agreement with those obtained by the chick growth assay for measuring the TDAA values in feedstuffs (Zuprizal *et al.* 1991). They suggested,

moreover, that the moist force-feeding method can replace the dry force-feeding technique of Sibbald (1976) in amino acid digestibility trials.

The aim of this current study was to study the effect of mixture of feedstuffs in diets on their TDP and TDAA values when the moist force-feeding method was used in cockerels. The effect of protein dilution on TDP and TDAA of diets was also investigated.

Materials and Methods

Feedstuffs and diets

Four feedstuffs (corn, whole and dehulled rapeseed meals, and soybean meal) were used in this experiment. For corn, the grains from a French cultivar (*Dea* a dent corn) were dried at ambient temperature ± 5°C which permitted the maintenance of physical and chemical qualitative characteristics of grains. The dry grain processing was made by the pilot industrial technological plant of Institut Technique des Cereales et des Fourrages, Boigneville, France (ITCF). Rapeseed meals were obtained from whole seeds (WRSM) or dehulled ones (DRSM). They were obtained from a French, very-low-glucosinolate cultivar (Samourai). They were processed by the pilot industrial technological plant of the Centre Technique Interprofessionnel des Oleagineux Metropolitains, Paris, France (CETIOM), where they were solvent-extracted, as a whole product, or after dehulling. The technical procedures of dehulling and oil extraction of the seeds have been described by Baudet *et al.* (1987). Soybean meal (SBM) of good quality was obtained from a commercial supplier in France[3].

Six experimental diets were formulated through the combination of four feedstuffs above (Table 3). Diets 1, 2, 3 and 4 contained 15, 17, 19 and 22% of crude protein (CP), respectively. However, diets 5 and 6 were as diets 4 and 1, respectively but were diluted with starch so as to obtain a CP content of about 11%. These last diets were formulated in order to study the effect of protein dilution on TDP and TDAA when the same feedstuffs were used in the diet.

Experimental procedure

In order to obtain the *measured* values of true digestibility of protein (TDP) and true digestibility of amino acids (TDAA) of diets, thirty-six intact adult cockerels (Isa Brown), one year of age, were used. Birds were housed in individual wire mesh cages, provided with water ad libitum, and received 16 h of artificial light per day. The room temperature was 21 ± 1° C. Trays were placed under cages for excreta collection. Birds were fasted for 24 h before force-feeding, in order to ensure complete emptying of their digestive tracts. Birds (six per diet) were then force-fed with 100 g (air-dry basis) of each diet. Each diet was moistened with an approximately equal weight of water, this being carefully mixed with the meal to give a homogeneous paste. The force-feeding technique and equipment were similar to those described by Lessire (1990).

Excreta were collected daily during the subsequent 48 h; they were freeze-dried, weighed (after equilibration with atmospheric moisture) and ground to pass through a 1 mm screen. Endogenous losses

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of nitrogen and amino acids were determined on fasted birds (six cockerels) for 72 h.

The *theoretical* values of TDP and TDAA were calculated from the individual digestibilty value of each feedstuff tested (Table 4) which was determined using the same groups of birds as those employed in the assay of the six diets above.

Chemical analysis

Sample of corn, WRSM, DRSM and SBM were analyzed for dry matter (DM), crude protein (CP) (N x 6.25) and ash by methods recommended by the Association of Official Analytical Chemists(AOAC, 1980). Water-insoluble cell walls (WICW) contents of four feedstuffs used were determined by the method of Carre and Brillouet (1989).

The amino acid contens of the diets and excreta were determined in the same conditions using an autoanalyzer[4] after 24 h acid hydrolysis with 6 M aqueous HCl at 115°C. Methionine and cystine were determined on sample oxidized with performic acid by the method of Moore (1963). Tryptophan was not determined. The method of Terpstra and de Hart (1974) was used to separate faecal nitrogen from urinary nitrogen for estimating protein digestibility.

Statistical analysis

The TDP and TDAA calculations were based on the formulae of Mohamed *et al.* (1989) and Likuski and Dorrell (1978), respectively. Statistical analysis were performed using analysis of variance and the comparison of means was done by Turkey's stest. The calculations were performed using a SYSTAT software program[5].

Results and Discussion

Feedstuffs

The composition of the feedstuffs used in the present experiment is shown in Table 1. The CP values of WRSM, DRSM and corn were lower than that of the SBM. However, dehulling before oil extraction increased the protein content of rapeseed from 40.1 to 46.6% on DM basis. This increase in protein content is the result of the decrease of CF (from 13.3 to 6.6%) or WICW (from 33.9 to 21.8%) contents in rapeseed meal (Table 1). These results are in good agreement with those reported by Lessire (1987) who found that dehulling the seed before oil extraction can reduce the CF content by up to 50%. The WICW value of 10.3% (DM basis) for corn is similar to that of 10.4% found by Carre (1992). Amino acid composition of WRSM, DRSM SBM and corn is shown in Table 2. Corn protein has higher levels of alanine, leucine, tyrosine and methionine, but lower of lysine and arginine that those of WRSM, DRSM and SBM. However, the amino acid content of the SBM protein is mostly higher than the WRSM and DRSM. Particularly, the contents of aspartic acid, serine, glutamic acid, isoleucine, leucine, tyrosine, phenylalanine, lysine and arginine are higher, while those of methionine, cystine, threonine and glycine are lower.

Theoretical and *measured* values of TDP and TDAA of diets.

The *theoretical* and *measured* values of TDP and TDAA of six diets tested in this experiment are shown in Table 5.

[4]Biotronik, Amino Acid Analyzer LC.5000. Postfach 1330, D-6457 Maintal 1, Germany
[5]Wilkinson, Leland, Systat Inc. Evanston, IL-60201

Table 1. Composition of raw materials tested

Ingredient	Crude protein	Crude fiber	WICW[1]	Ash
		(% DM)		
Whole rapeseed meal	40.1	13.3	33.9	9.4
Dehulled rapeseed meal	46.6	6.6	21.8	10.0
Soybean meal	52.7	4.0	18.1	7.2
Corn	10.7	2.4	10.3	1.2

[1]WICW = water-insoluble cell walls.

Table 2. Amino acids content of the raw materials tested

Amino acid	WRSM		DRSM		Soybean meal		Corn	
	(%DM)	(%CP)	(%DM)	(%CP)	(%DM)	(%CP)	(%DM)	(%CP)
Aspartic acid	3.23	8.05	4.21	9.03	6.59	12.50	0.76	7.10
Threonine	1.62	4.04	1.93	4.14	1.97	3.74	0.43	4.02
Serine	1.60	3.99	1.86	3.99	2.67	5.07	0.48	4.49
Glutamic acid	6.54	16.31	8.09	17.36	10.19	19.34	1.98	18.51
Alanine	1.73	4.31	2.20	4.72	2.36	4.48	0.79	7.38
Valine	1.89	4.71	2.31	4.96	2.50	4.74	0.47	4.39
Isoleucine	1.53	3.82	1.84	3.95	2.42	4.59	0.35	3.27
Leucine	2.50	6.23	3.19	6.85	3.92	7.44	1.22	11.40
Tyrosine	1.08	2.69	1.32	2.83	1.83	3.47	0.43	4.02
Phenylalanine	1.49	3.72	1.91	4.10	2.67	5.07	0.47	4.39
Lysine	2.19	5.46	2.49	5.34	3.29	6.24	0.30	2.80
Arginine	2.42	6.03	3.19	6.85	4.02	7.63	0.37	3.46
Cystine	1.21	3.02	1.51	3.24	0.91	1.73	0.26	1.87
Methionine	0.66	1.65	0.86	1.85	0.61	1.61	0.20	2.43

WRSM = rapeseed meal obtained from whole seed; DRSM = rapeseed meal obtained from dehulled seed.

Table 3. Composition of the experimental diets

Ingredients	Diets					
	1	2	3	4	5	6
Corn	75.50	71.70	66.30	60.00	30.00	56.80
Soybean meal		8.00	10.00	23.10	11.55	-
Dehulled rapeseed meal	2.60	4.80	10.00	10.00	5.00	1.95
Whole rapeseed meal	18.20	12.00	10.20	3.40	1.70	13.60
Starch	-	-	-	48.25	24.15	
Trace mineral premix[1]	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin premix[2]	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.40	0.40	0.40	0.40	0.40	0.40
Calcium carbonate	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.50	1.75	1.50	1.50	1.50	1.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Measured nutrients						
Ash (%)	5.03	5.10	5.50	5.70	4.43	4.54
Protein (%) (Nx6.25)	15.10	17.06	19.07	22.09	11.00	11.30
Calculated nutrients						
Protein (%) (Nx6.25)	15.00	17.00	19.00	20.00	10.00	11.00

[1]Premix provided the following per kilogram of diet: Co, 0.88 mg; Cu, 8.75 mg; I, 1.28 mg; Se, 15 mg; Zn, 100 mg; Fe, 35 mg; Mn, 110 mg.

[2]Premix provided the following per kilogram of diet: vitamin A, 10,000 IU; cholecalciferol, 1,500 ICU; vitamin E, 15 mg; butylated hydroxytoluence, 125 mg; menadione, 5 mg; riboflavin, 4 mg; pantothenic acid, 8 mg; niacin 25 mg; pyridoxine, 1 mg; vitamin B12, 0.008 mg; folacin, 2 mg; biotin, 0.1 mg; choline, 500 mg; thitamin, 0.5 mg.

The results of the current experiment indicated that there was no significant difference ($P > 0.05$) between *theoretical* and *measured* values for TDP in the six diets tested. The same results have been also reported by Schadereit *et al.* (1977) who showed that the protein digestibility values found for three broiler diets were very close to calculated values. However, there were significant differences ($P < 0.01$) between *theoretical* and *measured* values of TDAA where *measured* < *theoretical* for the

Table 4. True digestibility of protein (TDP) and amino acids (TDAA) of raw materials tested

	Corn	Soybean meal	Rapeseed meal[1] DRSM	Rapeseed meal[1] WRSM
TDP, (%)	85.7 ± 0.30	84.5 ± 2.61	83.2 ± 2.77	74.1 ± 2.27
TDAA, (%):				
Aspartic acid	79.3 ± 0.6	90.2 ± 0.99	86.9 ± 1.90	81.1 ± 1.80
Threonine	82.6 ± 0.6	87.8 ± 1.47	83.2 ± 1.47	76.4 ± 1.82
Serine	84.8 ± 0.4	91.9 ± 0.93	85.2 ± 2.01	78.1 ± 1.97
Glutamic acid	90.1 ± 0.4	92.4 ± 0.81	90.5 ± 1.90	86.7 ± 1.99
Alanine	86.1 ± 0.5	87.2 ± 1.99	84.9 ± 1.99	80.3 ± 1.76
Valine	82.5 ± 0.6	87.2 ± 1.23	86.4 ± 2.05	79.1 ± 2.53
Isoleucine	83.9 ± 0.5	89.4 ± 1.26	87.1 ± 2.06	80.5 ± 2.36
Leucine	91.5 ± 0.2	89.4 ± 1.05	87.5 ± 1.90	83.3 ± 1.87
Tyrosine	86.9 ± 0.5	89.2 ± 1.06	86.1 ± 2.43	78.1 ± 2.34
Phenylalanine	87.6 ± 0.5	90.0 ± 0.96	88.2 ± 1.74	82.5 ± 1.68
Lysine	71.4 ± 0.6	87.5 ± 1.63	83.1 ± 1.63	76.1 ± 1.73
Arginine	79.2 ± 1.0	85.2 ± 2.03	81.2 ± 1.91	81.9 ± 1.91
Cystine	87.4 ± 0.2	80.5 ± 1.80	79.1 ± 1.23	74.4 ± 1.20
Methionine	86.2 ± 0.2	95.6 ± 1.42	90.1 ± 1.30	86.7 ± 1.34

[1]WRSM = rapeseed meal obtained from whole seed; DRSM = rapeseed meal obtained from dehulled seed.

major part of amino acids. These results are in contrast with those obtained by Engster *et al.* (1985) who used mixtures containing 60.0% corn, 20.0% dehulled soybean meal, 10.0% meat meal, 5.0% wheat middlings and 5.0% corn gluten meal and found that the effect of mixed ingredients on TDAA values are additive. They observed, moreover, that the *measured* digestibility values of amino acids were generally higher that the *theoretical* ones in a range of almost 5%. However, it is difficult to compare our results to those of Engster *et al.* (1985) because the type of feedstuffs and their percentage used in both experiments were different. In fact, until present, the additivity of feedstuffs on true digestibility of amino acids values is not yet clear. Picard *et al.* (non published data, 1984) observed that the additivity effect depends on the type of feedstuffs used in the diet. When barley was mixed with soybean meal, they found that the *measured* values of true digestibility of amino acids were higher than those of *theoretical* ones. However, opposite results were observed, when rapeseed and soybean meals were mixed and used in the diets. So, further experiments are required to study the feedstuff effect on true digestibility of amino acids and separate them by group, according to their additive characteristic.

The effect of protein dilution on

Table 5. "Theoretical" and "Measured" values of true digestibility of protein (TDP) and amino acids (TDAA) of diets

	Diet											
	1		2		3		4		5		6	
	T[2]	M[3]	T	M	T	M	T	M	T	M	T	M
TDP, (%)	80.4	82.7 NS	82.1	83.3 NS	82.6	83.3 NS	83.8	83.5 NS	84.0	83.6 NS	80.4	82.7 NS
TDAA, (%):												
Aspartic acid	80.8	81.9 NS	85.4	82.2 **	85.0	80.9 *	87.2	81.0 **	87.2	80.6 **	80.8	79.7 NS
Threonine	79.9	76,9 NS	83.0	80.1 **	82.7	78.3 **	84.8	80.1 **	84.8	77.5 **	79.9	73.1 **
Serine	82.0	80.1 NS	86.1	84.7 NS	85.7	80.9 **	88.3	81.9 **	88.3	81.4 **	82.0	77.0 *
Glutamic acid	88.7	87.6 NS	90.9	88.8 **	90.2	87.6 *	91.2	86.9 **	91.2	85.4 **	88.7	86.6 NS
Alanine	84.1	84.0 NS	85.8	84.2 NS	85.2	83.0 NS	86.1	82.8 **	86.1	79.9 **	84.1	81.9 NS
Valine	81.3	84.3 NS	84.1	84.9 NS	83.9	83.4 NS	85.4	83.3 **	85.4	82.8 NS	81.3	81.3 NS
Isoleucine	82.6	82.2 NS	86.1	82.2 **	85.7	81.9 *	87.6	81.9 **	87.6	80.7 **	82.6	80.7 NS
Leucine	88.7	87.4 NS	90.0	87.4 **	89.1	85.5 **	89.6	84.6 **	89.6	83.5 **	88.7	86.7 NS
Tyrosine	83.8	83.5 NS	86.5	85.9 NS	86.0	85.6 NS	87.3	86.1 **	87.3	83.4 **	83.8	83.2 NS
Phenylalanine	85.6	86.0 NS	88.3	84.4 **	87.5	84.2 *	88.7	82.5 **	88.7	82.4 **	85.6	84.8 NS
Lysine	75.2	79.2 **	80.6	81.8 *	80.6	80.8 NS	83.6	81.4 **	83.6	81.9 NS	75.2	76.9 NS
Arginine	80.9	88.5 **	83.4	89.6 **	82.2	87.7 **	83.3	87.6 **	83.3	88.4 **	80.9	87.8 **
Cystine	80.3	78.7 NS	81.6	81.2 NS	80.8	81.7 NS	81.6	78.8 **	81.6	78.9 NS	80.3	78.1 NS
Methionine	86.7	84.5 NS	89.0	84.4 **	88.9	85.0 **	90.7	85.5 **	90.7	81.1 **	86.7	83.7 *

[1] Values with different superscript letters in the same column (for each diet) differ significantly; * = P<0.05; ** = P<0.01; and NS = non significant.
[2] T = Theoretical.
[3] M = Measured.

TDP and TDAA in diets is shown in Table 5 (diets: 4, 5 and 1, 6). Protein dilution had no significant effect on TDP and TDAA values. Using pure raw material, protein intake had also no significant effect on true digestibility of protein and amino acids (Zuprizal *et al.*, 1991). Similar results have been also reported by several authors (Sibbald, 1979, Green, 1987, McNab, 1989) who found that, under their experimental conditions, the true digestibility value is independent of protein intake.

Conclusions

The result of the current experiment indicated that there was no significant difference between *theoretical* and *measured* values for TDP in the six diets tested. However, there were significant differences between *theoretical* and *measured* values of

TDAA where *measured* < *theoretical* for the major part of amino acids. Protein dilution had no significant effect on TDP and TDAA values.

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