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Ileal *vs.* faecal amino acid digestibility in concentrates and fibrous sources for rabbit feed formulation

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ABSTRACT

This work studies in a wide range of ingredients what is the best amino acid evaluation for rabbit feed formulation. A semi-synthetic casein basal diet was designed for measuring the protein and amino acid endogenous flow. Another 11 diets, one for each ingredient (soybean meal, toasted full-fat soybean, soybean hulls, two types of sunflower meal (280 and 360 g/kg CP), peas, alfalfa meal, wheat, wheat shorts, maize, and corn gluten feed), were formulated in order to get the maximal proportion of the protein from the tested feedstuffs studied maintaining the chemical composition and dietary nitrogen endogenous flow. Ytterbium linked to fibre was used as a marker (4 g/kg). Twenty-eight New Zealand White × Californian doe rabbits fitted with a glass T-cannula at the ileum were fed the experimental diets *ad libitum* for 16 d (for 6 periods each). Feed intake and hard faeces excretion were recorded for each rabbit over a 4-d period (10–15 d). On days 15 and 16, ileal samples from each rabbit were collected under gravity for 1 h from 19:00 to 23:00 h to avoid the effect of the soft faeces excretion period on the protein ileal flow. The endogenous ileal flow of N was 512 mg/d as average and increased 6 mg/g of DMI ($P < 0.001$). Amino acids ileal endogenous flow varied from 399 mg/d for glutamic acid to 26 mg/d for methionine. Soybean meal and full-fat showed high (>0.90) and similar ($P > 0.05$) apparent faecal (AF) and true ileal (TI) N and amino acids digestibility, whereas those of soybean hulls were lower (0.653 and 0.529 for AF and TI N digestibility, respectively). Cereals and their by-products showed the highest differences between AF and TI N and amino acids digestibility, because they were well digested at ileal level (ranged from 0.809 to 0.880), whereas AF digestibility was lower (from 0.630 to 0.769). Likewise, sunflower meals, peas and alfalfa showed higher TI than AF digestibility, but this difference was only relevant (from 0.052 to 0.16 units) for some amino acids (Thr, Val, Ile, Leu, Lys, and Ala). The current work shows that the relative value among ingredients change depending on the digestibility unit used, and confirms that TI digestibility is the recommendable unit for feed formulation in rabbits.

1. Introduction

The reduction of nitrogen emission to the environment is nowadays one of the main objectives for the intensive animal rearing systems. Within the different possibilities existing to decrease these emissions, a better estimation of the digestible

Abbreviations: AF, apparent faecal; AI, apparent ileal; EN_F, endogenous nitrogen flow; N_F, ileal flow of nitrogen; $NNDF_F$, ileal flow of N linked to NDF; TI, true ileal.

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Table 1
Chemical composition (g/kg DM) of evaluated ingredients.

	Soybean meal 480[a]	Full-fat soybean	Soya bean hulls	Sunflower meal 280[a]	Sunflower meal 360[a]	Peas	Alfalfa meal	Wheat	Wheat shorts	Maize	Gluten feed
Dry matter	890	915	903	892	925	888	927	899	861	869	881
Ash	63.5	49.7	50.4	64.5	72.6	30.4	110	17.2	41.8	15.0	80.6
aNDFom	273	256	573	439	348	185	421	112	295	116	414
ADFom	91.9	96.3	430	298	212	94.6	298	46.7	95.2	35.0	117
Lignin (sa)	4.3	11.0	23.5	95.6	63.2	8.1	95.6	11.7	36.6	6.00	7.90
Ether extract	15.0	218	50.0	16.0	22.0	6.00	30.6	18.0	38.1	35.2	27.0
Nitrogen	86.4	70.7	26.1	49.0	66.6	45.3	29.3	25.0	29.8	19.0	37.9
Essential amino acids											
Arginine	41.0	35.4	11.9	29.1	38.7	26.4	9.20	9.16	12.2	7.19	9.37
Cystine	9.06	7.41	3.15	6.91	7.92	4.32	2.42	3.10	3.89	2.70	5.87
Histidine	13.5	11.4	4.70	8.70	10.8	6.60	3.87	3.63	4.59	3.22	7.53
Isoleucine	25.8	22.3	8.80	15.8	19.2	12.1	8.47	6.30	6.43	4.91	7.65
Leucine	39.3	33.6	13.0	21.9	27.5	18.8	13.1	10.7	11.3	13.1	20.1
Lysine	31.9	26.5	11.6	12.9	15.6	17.4	8.86	6.23	7.89	4.23	11.7
Methionine	6.64	5.57	2.45	7.66	9.70	2.94	2.80	2.62	2.84	2.26	3.86
Phenylalanine	28.4	22.8	8.10	15.6	19.8	12.5	11.9	6.94	8.38	5.87	8.04
Threonine	20.1	16.9	6.74	12.3	15.9	9.41	7.42	4.71	5.74	4.11	8.73
Valine	28.3	24.7	10.3	19.8	24.9	14.3	10.5	7.81	9.16	6.72	12.3
Non-essential amino acids											
Alanine	23.3	19.9	8.90	16.0	19.5	11.7	9.66	6.43	9.10	8.42	18.1
Aspartic acid	63.6	54.3	21.2	33.9	41.9	31.7	21.0	12.1	12.9	9.73	12.6
Glutamic acid	90.6	76.1	25.4	57.2	81.8	43.6	21.0	30.3	33.8	23.3	34.6
Glycine	22.5	19.3	12.3	21.1	25.8	12.1	8.93	6.21	9.07	4.77	11.3
Proline	24.7	20.1	9.30	14.3	18.1	11.6	12.5	11.4	12.2	9.65	23.1
Serine	25.2	20.7	8.80	12.6	17.2	11.0	7.53	6.12	6.89	4.52	9.63
Tyrosine	20.1	17.4	7.20	9.00	12.2	9.00	7.36	4.61	5.14	4.34	8.00

[a] The figures indicate g/kg of CP.

protein and amino acids content of the most common feedstuffs used in animal nutrition can be considered as one of the most important. This improvement in nitrogen assessment would allow a better adjustment to the animal requirements avoiding an excess of nutrients in the diet that would finally be excreted to the environment. In non-ruminant species, the use of the ileal balance corrected by endogenous flow (standardized nitrogen digestibility) instead of faecal balances and apparent digestibilities has been proposed as the best unit for nitrogen evaluation (Chung and Baker, 1992; Nyachoti et al., 1997; Mosenthin et al., 2000). In rabbits, the most common procedure for nitrogen evaluation of a feedstuff has been the faecal balance. However, García et al. (2005) and Carabaño et al. (2009) showed that the use of apparent ileal and faecal digestibility in rabbits lead to an underestimation of the nitrogen and amino acid content utilization of different feedstuffs compared with the true ileal digestibility. Ileal digesta of rabbits contains large amounts of nitrogen of endogenous origin: 3.8 g CP/100 g of dry matter intake (DMI) (García et al., 2004) originated from digestive enzymes, mucoproteins, desquamated cells, urea and amino acids produced by cellular breakdown and micro-organism. This endogenous nitrogen obtained from rabbits fed with a protein (casein) containing-diet is 3.2 times higher in rabbits than in pigs fed nitrogen free diets (Boisen and Moughan, 1996; Jansman et al., 2002; Stein et al., 2007). So, as in other non-ruminant species and in order to formulate balanced low-protein diets, the use of true ileal digestibility in rabbits is also recommended. Nevertheless, data concerning true ileal digestible nitrogen and amino acid content of feedstuffs commonly used in rabbit feeds are scarce.

According to a recent European research on nutritional evaluation (Villamide et al., 2009), rabbit feeds contain a wide variety of raw materials (35 different feedstuffs and 11 as average per diet), although most of them are included at very low level, as fibrous sources, being their nitrogen supply scarce. Dietary nitrogen comes mainly from soybean and sunflower meal (40%), alfalfa (25%), cereals and their by-products (30%). The aim of this work has been to compare apparent faecal and true ileal amino acid digestibility of a wide range of raw materials used in rabbit feed formulation.

2. Materials and methods

2.1. Feeds and diets

A total of 11 raw materials, supplying most of nitrogen content in rabbit diets, were selected for their nitrogen assessment. Five products came from the two main oil seed meals (soybean meal, toasted full-fat soybean, soybean hulls, sunflower meal 280 and 360 g/kg of CP), and the other six were peas, alfalfa meal, and two cereals and their by-products (wheat, wheat shorts, maize, and corn gluten feed). The chemical composition of the selected feedstuffs is presented in Table 1.

A semi-synthetic casein basal diet was designed for measuring the total nitrogen and amino acid endogenous flow. Starch and soybean oil were used as energy sources whereas a mixture of pectin, cellulose, sunflower hulls and NaOH treated straw were used as fibrous sources in order to meet the present recommendations of level and type of fibre (De Blas and Mateos,