KRMIVA

IDEAL PROTEIN FOR PIGS AND POULTRY

IDEALNA BJELANČEVINA ZA SVINJE I PERAD

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Pregledno znanstveni članak
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SUMMARY

The concept of ideal protein is a rather new, innovative step into amino acid nutrition.

It is a valid tool in the evaluation of amino acid requirements and new raw materials. In the formulation of diets with reduced protein content it makes possible to calculate the limitations expressed by the minimum requirements in nonessential amino acids and in indispensable amino acids.

The factorial approach makes adapting the profile to different age and different levels of performance possible.

INTRODUCTION

Today it is generally accepted to use crystalline amino acids in the formulation of diets for swine and poultry. Increasing usage of new raw materials and cereals and the higher densities in special areas in animal production cause new thoughts on environmental-friendly production. Minimizing the animal excretion of nitrogen and phosphorus and reducing emission from animal production facilities therefore is a necessity today. This is whay new restrictions on protein and minerals in the formulation of diets for pigs and poultry are discussed and are even widely accepted. Besides methionine and lysine, the most limiting amino acids in the diets for poultry and pigs, threonine and tryptophan are also available today and used in the diets for young growing livestock.

THE IDEAL PROTEIN CONCEPT

In 1981 the ARC (British Agriculture Research Council) first published recommendations based on the ideal protein concept. This was a bold step and an innovative move in the concept of amino acid nutrition. High valued natural proteins as protein standards have been replaced with the concept of an amino acid profile based on requirement data. The ideal protein is an amino acid profile, that fulfills the animal needs on amino adics withno surplus or deficiency.

In the ideal protein concept, the indispensable amino acids are listed as ratios (or percentages) of lysine. Lysine was chosen as the reference for several reasons:

1. Lysine in most diets is the first-limiting amino acid and the content in the diet, therefore, corresponds to performance.

2. Lysine in the metabolism has a sole function for protein synthesis (only lysine of endogenous origin, i.e. trimethyl lysine, is used for carnitine synthesis).

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3. The analysis of lysine in feedstuffs and raw materials presents no problems and the information on the contents in the feedstuffs is mostly sufficient.

There are different ways to express the ideal protein, one exact form is the expression in g amino acid / 100 g protein (16 g N), but for practical reasons the relative expression as a percentage of lysine is the most commonly used form.

The ideal protein for pigs formulated by the ARC (1981) has not shown to be so good, as it could be improved by the supplementation of amino acids e.g. methionine. Therefore in different institutes research is carried out to improve the concept. A new approach has been found by Fuller et al. (1989) at the Rowett Research Institute and by Baker and Chung (1992) at the University of Illinois. Table 1 shows the profiles for young growing pigs developed by these researchers.

Table 1. Ideal protein pattern for pigs

Tablica 1. Idealna shema bjelančevina za svinje

Amino acids	Wang&Fuller (1990)	(Chung&Baker) (1992)
Lysine	100	100
Met+Cys	61	60
Threonine	64	65
Tryptophan	20	18
Arginine	N.E.	42
Histidine	N.E.	32
Isoleucine	60	60
Leucine	111	100
Phenylala.+tyrosine	120	95
Valine	75	68

With regard to the factorial approach the main needs of the animal result from protein accretion and maintenance. In Table 2 the data are listed separately and show big differences between the two profiles. As the profile of protein accretion corresponds to the contents in lean meat or muscle, the profile for maintenance is dominated by the amino acids with separate functions on the metabolism. The needs for methionine + cystine and threonine in maintenance surpass the needs for lysine by about 150% whereas in protein accretion these needs are between 60 and 70% of the lysine requirements.

Table 2: Ideal protein for fattening pigs

Tablica 2: Idealne bjelančevine za tovne svinje

Wang and Fuller et al. 1989
Fuller et al. 1989, Wang and Fuller 1990

	Maintenance Uzdržne potrebe	Protein deposition Odlaganje bjelančevina	Recommendation Preporuke	
	%	%	g/16 g N	%
Lysine	100	100	6.5	100
Methionine+Cystine	142	53	3.9	60
Methionine	30	28	-	-
Threonine	142	69	4.3	66
Tryptophan	30	18	1.2	19
Isoleucine	46	63	3.9	60
Leucine	67	114	7.2	111
Valine	54	77	4.9	75
Phenylal.+Tyr.	114	123	7.8	120

At the University of Illinois, therefore, dynamic profiles for growing pigs have been developed. The basis for these calculations as they are shown in Table 3, are trials with synthetic rations based on pure nutrients and crystalline amino acids.

Table 3: Ideal protein for swine

Tablica 3: Idealne bjelančevine za svinju

Baker&Chung 1992

	5 - 20 kg	20 - 50 kg	50 - 100 kg
Lysine	100	100	100
Methionine+ +Cystine	60	65	70
Threonine	65	67	70
Tryptophan	18	19	20
Isoleucine	60	60	60
Leucine	100	100	100
Valine	68	68	68

Table 4: Amino acid intake for best performance of lactating sows

Tablica 4: Uzimanje amino kiselina za najbolju performansu krmača dojilja

Schneider et al., 1992

Amino acids - Amino kiseline	Intake (g/day) - Uzimanje	Relative (%)
Lys	39.4	100
Met+Cys	30.2	76
Thr	26.0	66
Trp	8.2	21

Maintenance gets a more important part in the older animals. As the level of protein accretion in the fattening period is rather stable and depends more on the genetics than on the nutrition system, the differences in the profile of the ideal protein in this period are caused by the increasing part of maintenance.

This influence on amino acid requirement could be observed in mature lactating sows, too. Trials evaluating the amino acid requirement of lactating sows resulted for the four most important acids lysine, methionine + cystine, threonine and tryptophan in the profile as shown in Table 4 (Schneider et al. 1992).

DIETARY FACTORS INFLUENCING THE IDEAL PROTEIN CONCEPT

In some recently published trials by Markert et al. (1992, 1993) the optimal density of ideal protein for swine has been developed. Using low protein diets based on cereals and peas in metabolism trials he evaluated the optimal lysine concentration in the ideal protein and a ration between essential and dispensable amino acids. In the diets the amino acid contents have been adapted to the profile for an ideal protein as published by Wang and Fuller (1990).

The optimal lysine concentration (Figure 1) turned out to be in range of 7-7,5% and corresponds very well to the values given by the ARC (1981). The optimal ratio between essential and dispensable amino acids turned out be about 45:55 (Figure 2).

Figure 1: Nitrogen accretion of pigs related to the lys: protein ratio (live weight: 40-60 kg)

Slika 1: Povećanje dušika u svinja u svezi s omjerom lizin : bjelančevina (živa vaga: 40-60 kg)

Market et al. 1993

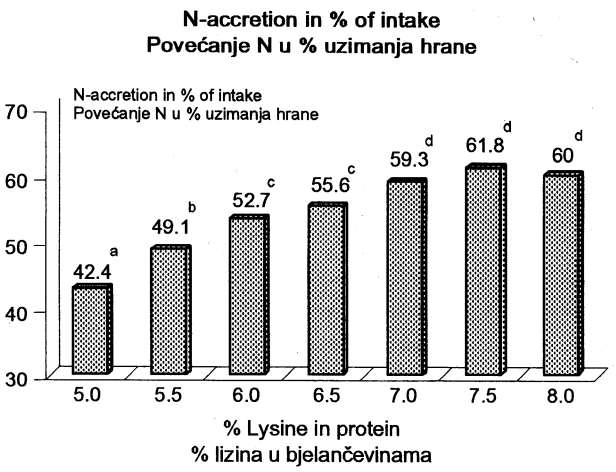
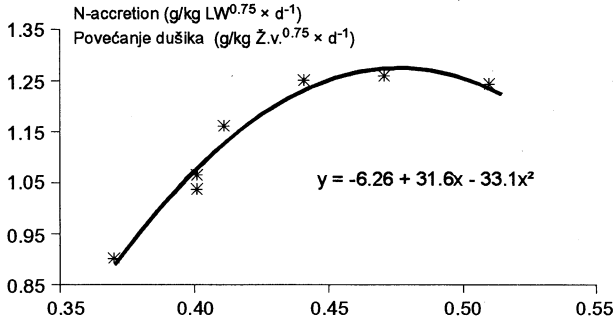


Figure 2: Influence of the ratio of essential amino acids and protein on the N-accretion of pigs (live weight: 40-60 kg)

Slika 2: Utjecaj omjera esencijalnih amino kiselina i bjelančevina na povećanje dušika u svinja (Živa vaga: 40-60 kg)

Markert et al., 1993



In the third part of this research project the influence of energy on the efficiency of an ideal protein has been evaluated. Results of the work are given in Figure 3 and 4 and show an increasing effect of energy supply on the nitrogen balance. The excretion of nitrogen in urine is linearly decreased with optimized energy supply. These figures allow the calculation for the minimum supply with protein for growing pigs. In Table 5, the minimum protein requirement for the periods 20-30 kg, 30-55 kg, 56-100 kg have been listed with 13,6%, 11,7%, and 9,5% of the diet. These values represent the minimum of the protein requirement with the optimal ratio between indispensable and dispensable amino acids and with essential amino acids in an optimal profile without surplus and deficiencies.

Figure 3: N-excretion in feces and urine related to the energy intake

Slika 3: Izlučivanje dušika izmetom i mokraćom u svezi s uzimanjem energije

Kirchgessner 1994

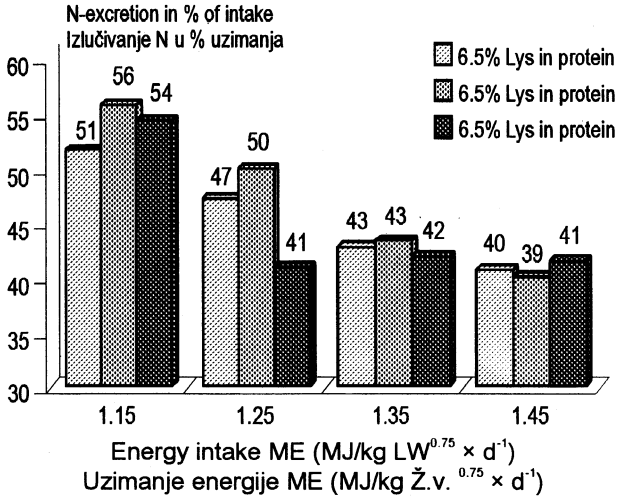


Figure 4: N-accretion and n-excretion related to the lysine: energy ratio

Slika 4: Povećanje i izlučivanje dušika u svezi s omjerom lizin : energija

Kirchgessner 1994

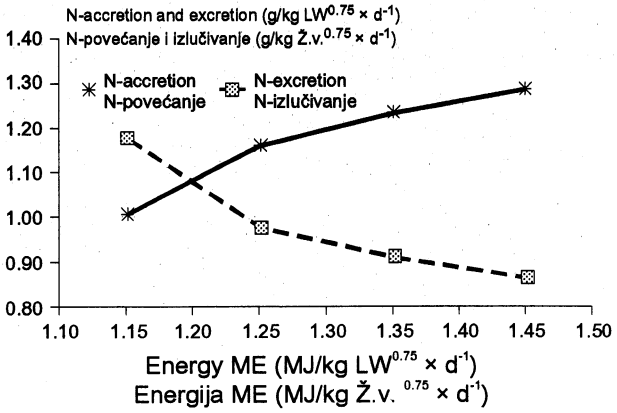


Table 5: Calculated minimum contents of ideal protein in swine feed

Tablica 5: Izračunati najmanji sadržaj i idealne bjelančevine u hrani za svinje

Live weight Živa vaga	20-30 kg	30-55 kg	56-100 kg
Contents per kg feed: Sadržaj u kg hrane:			
energy ME (MJ/kg) energija ME (MJ/kg)	13.2	13.0	13.0
lysine, total (%) lizin, ukupni (%)	1.08	0.95	0.78
lysine, ileal digest. (%) lizin, ilealna prob. (%)	0.89	0.76	0.62
Minimum content (% of diet)*: Najmanji sadržaj (% hrane)*:			
ideal protein (%) idealne bjelančevine (%)	13.6	11.7	9.5
essential AA (%) esencijalne AK (%)	6.1	5.3	5.2
non-essential AA ne-esencijalne AK	7.5	6.4	5.2

*on basis 6,5% lysine
*na osnovi 6,5% lizina

THE IDEAL PROTEIN CONCEPT FOR POULTRY

The factors listed for swine are also effective in poultry nutrition. The requirement data for amino acids in poultry show other profiles than in swine, but nevertheless ME and crude protein level as well as age of the birds, genetics and sex influence the individual amino acid requirement.

There is one main point in the amino acid requirement of poultry, that causes a special profile in the young growing bird. Figure 5 shows the effect of feathering with regard to the methionine and cystine requirement.

In Table 6 the different amino acid profiles of body protein, feather protein and maintenance requirements are listed. The lysine content in body protein is rather high, being about twice as high as threonine or the sulfur amino acid portion. In feather protein, however, lysine is very low, whereas the sulphur amino acids are extremely high due to the cystine content in feathers.

Figure 5: Net requirement of amino acids in broilers

Slika 5: Netto potrebe za aminokiselinama u brojlera

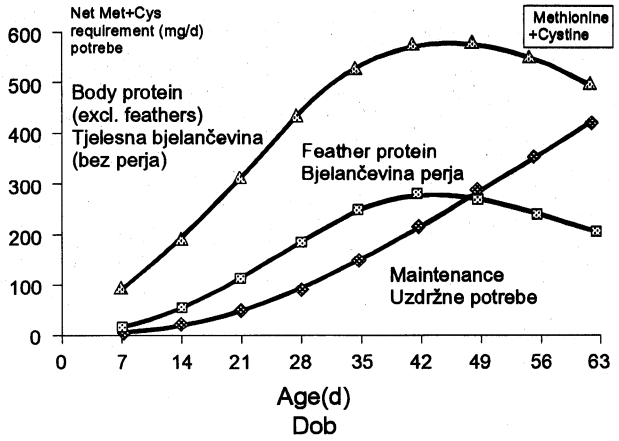


Table 6: Amino acid composition
Tablica 6: Sastav amino kiselina

	Body[1] protein Tjelesne bjelančevine		Feather[1] protein Bjelančevine perja		Maintenance[2] Uzdržive potrebe	
	g/16 g N	(% of lys)	g/16 g N	(% of lys)	mg/kg BW/d (Ž.v.)	(% of lys)
Lysine	7.5	(100)	1.8	(100)	29	(100)
Methionine	2.5	(33)	0.6	(33)	- -	
Met+Cys	3.6	(48)	7.6	(420)	113	(390)
Threonine	4.2	(56)	4.4	(240)	74	(250)
Tryptophan	1.0	(13)	0.7	(39)	19	(66)
Arginine	6.8	(91)	6.5	(360)	120	(410)
Valine	4.4	(59)	6.0	(330)	61	(210)
Leucine	7.1	(95)	7.0	(390)	124	(430)
Isoleucine	4.0	(53)	4.0	(220)	72	(250)

1) Fisher 1993

2) Leveille et al. 1960

The profile for maintenance requirement is not too far from the swine data.

The first attempt to specify an ideal protein for broiler chicks was done by Baker at the University of Illinois.

Based on growth studies with crystalline amino acid diets in starting chicks Baker & Han (1994) suggested ratios of 72, 67, 16 and 105 for the digestible Methionine+Cystine, Threonine, Tryptophan and Arginine relative to digestible Lysine.

For older birds, they recommend elevated levels of sulphur amino acids, threonine and tryptophan relative to lysine.

The Illinois ideal protein for different age given by Baker & Han (1994) is listed in Table 7.

Table 7: Ideal protein for broilers as proposed by dr. baker, illinois

Tablica 7: Idealna bjelančevina za brojlere kako je predložio dr. Baker, Illinois

Digestible AA Probavljive AK	Starter Početna	Grower Porast
	0-21 d	21-42 d
Lysine	100	100
Methionine	36	37
Cystine	36	38
Methionine+Cystine	72	75
Threonine	67	70
Tryptophan	16	17
Arginine	105	105
Valine	77	77
Leucine	109	109
Isoleucine	67	67

Baker & Han 1994
California Nutr. Conf., 21-24

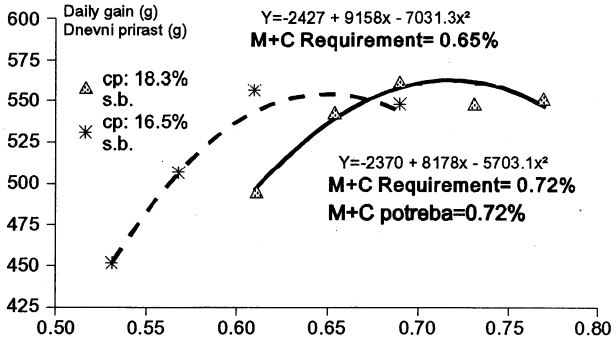
INTERACTIONS BETWEEN PROTEIN AND AMINO ACIDS

For a long time, high protein nutrition in pigs and poultry stood for quality. Nevertheless, research work shows, that a surplus of protein not only has to be deaminated and used in energy metabolism, but this also has negative effects on the energy conversion.

Evaluating the methionine requirement at different protein levels in pig feeding, there was an increase in the requirement changing protein from 16,5% to 18,3% (Koch and Schutte, 1991) Figure 6.

Figure 6: Methionine+Cystine-requirement of piglets fed diets with different crude protein levels (live weight: 11.4-30.0 kg)

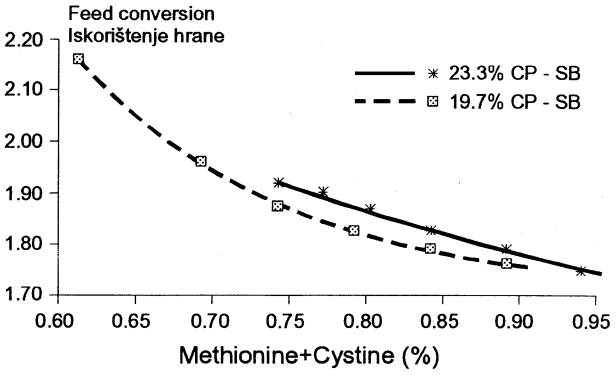
Slika 6: Potrebe Metonin+Cistin peradi hranjene hranom s različitim količinama sirovih bjelančevine (živa vaga: 11.4-30.0 kg)



Considering the results in broiler nutrition it seems, there is the same situation. As is shown in Figure 7 an increase in the protein content from 19,7 to 23,3% CP caused a reduction in gain per kg feed and in gain/g at the same Met+Cys level (Huyghebaert et al, 1994).

Figure 7: The effect of dietary protein on the response of broilers to sulphur amino acids (14-35 days of age)

Slika 7: Učinak bjelančevina u hrani na reakciju brojlera na sumporne amino kiseline (14-35 dana starosti)



Huyghebaert & Pack 1994
Proc. 9th Europ. Poult. Conf., Glasgow

Thus, we have to consider, that increase in protein content is followed by higher needs in the essential amino acids, but not necessarily in improvement of performance.

DIGESTIBLE AMINO ACIDS

The ideal protein concept is based on digestible amino acids.

Fuller et al. (1989) as well as Baker and Han (1994) used highly digestible raw materials like casein or crystalline amino acids with digestibility near 100%. This means that their data correspond to the digestible amino acid concept. The optimal profile, therefore may change being transfered to total amino acid contents of the diets.

Table 8 shows the comparison of two diets used in a pig trial recently carried out. The optimal relation between the apparent ileal digestible amino acids and the total contents vary, corresponding to different digestibility of the amino acids. These differences are more specific with overall low digestible raw materials in the diets.

Table 8: AA contents of the high and the low digestible diet

Tablica 8: Sadržaj AK visoko i nisko probavljive hrane

	total	% of	ileal	% of	total	% of	ileal	% of
	(%)	lys	(%)	il.lys	(%)	lys	(%)	il. lys
Met	0.26	30	0.22	31	0.30	33	0.25	36
Met+Cys	0.54	63	0.42	60	0.59	65	0.42	60
Lys	0.86	100	0.70	100	0.91	100	0.70	100
Thr	0.48	58	0.32	46	0.54	59	0.33	47
Trp	0.19	22	0.14	20	0.19	21	0.14	20
Arg	0.87	101	0.73	104	0.89	98	0.71	101
Val	0.63	73	0.47	67	0.71	78	0.49	70
Leu	1.00	116	0.78	111	1.21	133	0.93	133
Ile	0.53	62	0.41	59	0.53	58	0.37	53
CP - SB	12.2				11.7			
NE (MJ/kg)	14.7				15.1			
Ca	0.68				0.68			
P	0.19				0.19			

LITERATURA

1. ARC, (1981): The nutriment requirements of pigs Commonwealth Agricultural Bureau Slough, Engl. 307
2. Baker, D.H., Y. Han. (1994): Ideal protein and amino acid requirement of broiler chicks Calif. Nutr. Conference 21-24.
3. Baker, D.H., Y. Han (1994): Ideal amino acid profil for chicks during the first three weeks posthatching Poultry Sci. 73, 1441-1447
4. Baker, D.H., T.K. Chung, (1992): Ideal protein for swine and poultry, Biokyowa Techn. Review 4
5. Edmonds, M.S., D.H. Baker (1987): Amino acid excesses for young pigs J. Anim. Sci 64, 1664-1671
6. Fuller, M.F.; R. Mc William, T.C. Wang, L.R. Giles, (1989): The optimum dietary amino acid pattern for growing pigs Brit. Journ. Nutr. 62, 255-267
7. Huygebaert, G., M. Pack, G. de Groote, (1994): Influence of protein concentration on the response of broilers to supplemental DL-methionine

   Archiv für Geflügelkunde 58 (1), 23-29
8. Koch, F. B. Schutte, (1991): Einfluß des Futterproteins auf den Methioninbedarf des Schweines 103. VdLUFA-Kongreß, Ulm 16.-21. Sept, Nr. 3, 469-474
9. Markert. W. (1992): Bilanzstudien beim Schwein zur Reduzierung der Stickstoff-Ausscheidung durch Proteinabsenkung und den Einsatz von Aminosäuren Diss. Techn. Univ. München
10. Schneider, R., M. Kirchgeßner, B. Paulicks, F.-J. Schwarz, (1992): Zum Bedarf laktierender Sauen an schwefelhaltigen Aminosäuren J. Anim. Physiol. and Anim. Nutr. 68, 235-243
11. Wang, T.C., M.F. Fuller, (1990): The effect of the plane of nutrition on the optimum dietary amino acid pattern for growing pigs. Amin. Prod. 50, 155-164

SAŽETAK

Pojam idealne bjelančevine razmjerno je nov i novatorski korak u prehrani amino kiselinama.

To je vrijedno sredstvo u procjeni potreba za amino kiselinama kao i za procjenu novih sirovina. Pri sastavljanju onih vrsta prehrane gdje su smanjeni sadržaji bjelančevina to omogućuje izračunavanje granica izraženih minimalnim potrebama za neesencijalnim amino kiselinama kao i za esencijalnim amino kiselinama. Ovaj faktorijelni pristup pruža mogućnosti prilagodbe ovog profila raznoj dobi i različitim razinama performanse.