METHODS OF EXPRESSION OF FEED'S PROTEIN NUTRITIONAL VALUE

MODALITĂŢI DE EXPRIMARE A VALORII NUTRITIVE PROTEICE A NUTREŢURILOR

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Abstract: *The systems expressing the protein nutritional value of feed should allow the expressing in the same unit. The selection of expressing method is different according to species and depends on: the bigger or smaller variability degree of successive Nitrogen losses, either in the digestive utilization or in the metabolic one; possibility of knowing or express as accurately as possible these losses, according to feed or animals' own characteristics. The utilization of aminoacids for protein synthesis occurs with Nitrogen excretion at urinary level, mainly as urea. The measure of this fraction depends on the crude protein amount ingested and especially on the quality of feed used in swine nutrition.*

Key words*: feed, nutritional value, protein, pig*

INTRODUCTION

In monogastric species, the digestive utilization presents a reduced variability, and the metabolic utilization depends mainly on the participation of essential aminoacids. Consequently, in pig, feed's protein nutritional value (like the protein requirements) is best expressed as crude protein (CP), crude essential aminoacids and digestible essential aminoacids.

All proteins are consisted of simple units, called aminoacids. Although there are more than 200 aminoacids identified in the nature, only 20 of them are common elements for proteins: glicocol, alanine, serine, threonine, valine, leucine, isoleucine, aspartic acid, glutamic acid,

hydroxyglutamic acid, arginine, lysine, cystine, methionine, phenylalanine, tyrosine, tryptophan, histidine, proline and hydroxyproline [2, 6]. Some of the aminoacids cannot be synthesized or are synthesized too slowly to face the requirements: these are called essential or indispensable aminoacids. In turn, these aminoacids may be classified in strictly essential aminoacids, which compulsory must be present in feed, because animals are absolutely incapable of synthesizing; for all species, these are lysine and threonine. There is also another category of essential aminoacids, namely the widely essential aminoacids, which may be synthesized starting from other aminoacids, but in amounts that are too reduced to meet animals' requirements; these are: arginine, histidine, isoleucine, methionine, phenylalanine, tryptophan and valine [1, 3].

Finally, there is the group of semi-essential aminoacids, which may be synthesized in sufficient quantities, starting from other aminoacids; this is the case of cystine and tyrosine, and they may be produced starting from methionine, respectively phenylalanine. However, all these 10 essential aminoacids are present in small amounts in vegetal proteins.The second big group of aminoacids is the one of non-essential aminoacids. The animal organism is able to produce them starting from other aminoacids, due to the reaction of transamination.

RESULTS AND DISCUSSIONS

The aminoacid availability may be defined as the proportion the aminoacid is used for protein synthesis, if it represents the only ratio limiting factor.The availability may be associated only with the aminoacids that may be limited in a certain diet. For example, lysine plays a preponderant role from this point of view, due to its strictly indispensable character, to its reduced concentration in several feed types (especially cereals) and because the amino groups are susceptible of interfering with glucides and lipids.The methods applied in the determination of aminoacid availability may be classified as follows:

– *chemical methods,* excluding the animal, suppose the direct determination of feed aminoacids with the help of some reagents. Usually, these methods aim at the determination of availability in the animal-origin protein.

– *methods relied on free aminoacid dosage* – are methods that may be defined by the amount of aminoacids absorbed and recovered in blood (poartal vein) or by the amount of aminoacids from the peripheral blood and tissues. The multitude of influence factors that may change the blood and tissue's concentration in free aminoacids (feeding method, sampling hour, energy sources, genetic type and animals' individual variability) make this method's precision be insufficient sometimes.

– *„in vitro" methods*, represented by aminoacid determination through enzymatic hydrolysis, represent a progress compared with the simple dosage of free aminoacids; however, they do not reproduce accurately the physiological conditions of digestion. Such methods may be used as indicators for enzymatic digestion, but do not consider aspects related to intestinal absorption or to the utilization of aminoacids in protein synthesis.

– *„in vivo" methods*, relied on the proportion of absorbed aminoacids at the digestive tract level or at ileum level, allow a better assessment of aminoacid availability, although they neglect the role played by intestinal flora (in the case of global digestibility determination) and, on the hole, by all factors that change digestion's physiology and may influence aminoacid availability.

– *„growth" methods* – determine animals' weight growth or protein growth successive to the ingestion of protein or aminoacid. This practically represents an expensive method (requires big number of animals and long experimental periods) and it theoretically lacks specificity (the growth performances do not depend only on the participation of the available aminoacid studied).

Of all the methods presented, we may consider that the method determining protein digestibility at ileum level is the future's method, provided that the still existent methodological problems will be solved.

Proteins are only partially used by animals during the processes of digestion and metabolism.

During the digestive utilization of feed-based Nitrogen, the undigested part of this gets into faeces, in a relative proportion compared with the ingested Nitrogen, which depends on species and ratio category and content.

The metabolic utilization of sanguine aminoacids for protein synthesis may be expressed through Nitrogen excretion at urinary level,

especially as urea. The measure of this fraction depends on the ingested amount of crude protein and on its quality.

The importance of Nitrogen losses may be characterized at digestive level by apparent digestive utilization coefficients (CUD) and by real digestive utilization coefficients (CUDr), and at metabolic level by apparent metabolic utilization coefficients (CUMa) and by real metabolic utilization coefficients (CUMr). The last ones are known as protein biological value (VB).

The calculation relationships of CUMa and CUMr are:

$$CUMa = \frac{\text{apparently fixed N}}{\text{apparently absorbed N}} = \frac{Ni - (NFt + NUt)}{Ni - NFt}$$

$$CUMr = \frac{\text{really fixed N}}{(VB)\ \text{really absorbed N}} = \frac{Ni - (NFa + NUa)}{Ni - NFa} = \frac{Ni - [(NFt - NFe) + (NUt - NUe)]}{Ni - (NFt - NFe)}$$

where: Ni = ingested Nitrogen: NFa = food-origin faeces Nitrogen; NFe = endogenous-origin faeces Nitrogen; NFt = total faeces Nitrogen = Nfa + Nfe; Nua = food-origin urine Nitrogen; Nue = endogenous-origin urine Nitrogen; Nut = total urine Nitrogen = Nua + Nue

The variability of metabolic utilization coefficients (CUM), in relationship with the animal, exclusively concerns the physiological individual characteristics, age, sex, physiological stage; the species influences CUM in a reduced proportion.

Feed characteristics exert a determined influence on CUM, especially feed's content in protein and essential aminoacids; this is the condition necessary for a maximal metabolic utilization.

The aminoacids necessary for protein synthesis must be present in ratios and also must arrive at the same time at synthesis location, in proportions that are identical with the ones of the proteins that are to be synthesized. Everything that may delay aminoacids' arrival at cells will reduce the protein synthesis and implicitly the values of metabolic utilization coefficients. This also explains the notion of antitriptic factor, present in soybean, which delays methionine secretion (which is available in small amounts anyway).

If we compare several different protein sources, we may observe that the maximal CUM is as bigger as the protein source is better balanced in

aminoacids (egg >grit > gluten) and, consequently, the optimal level is as smaller as the maximal CUM is bigger, namely if the protein source is of good quality.

Beside the optimal protein level, the excessive Nitrogen waste explains the reduction of CUM. However, the selection of a good-quality protein source, with a high content in essential aminoacids, determines the reduction of optimal protein level in ratio. This is the explanation for the fact that the utilization of synthesis aminoacids generates the amelioration of ratio's aminoacid balance and allows the reduction of crude protein level.This protein saving has many important consequences, especially the reduction of ratio cost and the reduction of Nitrogen-based residues, implicitly of pollution.

Finally, at cell level, the protein synthesis requires an optimal energy level, mineral salts and vitamins. If the energy input is insufficient, this becomes a factor that limits protein synthesis. This is the reason why the aminoacid requirement may be expressed in relationship with ratio's energy level. If an essential aminoacid is absent at protein synthesis level, this means the reduction of performances and the increase of the specific intake. We may also observe an increase of urinary Nitrogen excretion, because other aminoacids, present in excess at the protein synthesis location, cannot be entirely used.

The aminoacid that, in an insufficient amount, limits cell protein synthesis, is called "limiting factor"; its participation regulates protein synthesis and, consequently, the efficiency of feed-protein utilization.

A theoretical example that illustrates this notion of limiting factor is presented in table 1, where the cell protein to be synthesized is consisted of 3 aminoacids a, b and c in the proportions: 9a, 5b and 3c. The distribution of feed proteins (p1, p2, p3 and p4), which comes progressively close to the distribution of cell proteins, leads to an increasing amelioration of protein synthesis and to a reduction of urinary Nitrogen excretion. The aminoacid „c" represents a factor limiting the proteins p1, p2 and p3, but not the protein p4 [2, 4, 6].

Table 1. Effects of distribution of food proteins on proteosynthesis and urinary Nitrogen excretion

				Proteosynthesis	Urinary Nitrogen excretion
Cell proteins	**9a**	**5b**	**3c**		
Feed proteins					
p1	9a	5b		0	+++
p2	9a	5b	c	+	+++
P3	9a	5b	c	++	++
P4	9a	5b	c	++++	0

Source: processed in concordance with different authors

According to the specialty literature, we may consider that beside the three known limiting aminoacids (lysine, methionine and tryptophan), there is one more aminoacid, namely the threonine (these four aminoacids are the only ones used at industrial level at the moment). And this is because it exerts an obvious effect on muscle development and is a glucoformateur (with important effects especially for piglets during crisis periods, when they eat less feed).

We should also mention that the excessive participation of some aminoacids cannot be stored or may be stored only for short periods (catabolised and excreted). On the contrary, an aminoacid recognized as non-essential may become a limiting factor if its nutritional participation is insufficient or if the essential aminoacids are supplied limited, not allowing in this way the synthesis of the non-essential aminoacids.

The ideal protein may be defined as the protein that allows a maximal protein synthesis, due to its content in essential aminoacids. These aminoacids may be present with constant proportions between them, according to the content in the same aminoacids of the stored or synthesized proteins.

For a value of 100% of lysine requirement, the relative values of the requirements for tryptophan and methionine + cystine are 18, respectively 60. For example, if the ratio lysine/ED is fixed at 3.7 g/1000 kcal ED, the tryptophan participation must be [2, 4]:

3.7 x 18/100 = 0.7 g/1000 kcal ED

The objects of the ideal protein system are related to: -the reduction of ratio protein level, by limiting the excessive participations of some non-essential aminoacids and maintaining the same performances; the consecutive reduction of Nitrogen losses through urine; for example, in the

case of the growing pig, in comparison with a ratio including 17% CP, a diet including 14% CP rebalanced in aminoacids means a reduction of approximately 20% of the Nitrogen-based by-products excreted; the completion of energy savings, because the same amount of protein fixed requires less energy (the replacement of a crude protein part with starch determines the reduction of extra-warmth production).

Table 2 presents 4 combinations wheat + soybean grit + other components, in relationship with the concept of ideal protein [2, 4, 6]. These 4 formulae allow the attaining of the desired balance, very similar with the ideal protein. Formula 1 allows it without synthesis aminoacids, but with 22.6% CP. The introduction of these allows the reestablishment of the optimal ratios specific to the ideal protein and to reach only 17% CP in formula 4.

Table 2. Simplified wheat + soy grits through the prism of the concept of ideal protein

Specifications	1	2	3	4
Wheat (%)	61.50	67.32	73.74	78.65
Soybean grit (%)	34.30	28.20	21.40	16.20
Lysine HCI (%)	-	0.20	0.42	0.59
DL threonine (%)	-	0.05	0.15	0.22
DL methionine (%)	-	0.03	0.09	0.14
Minerals + vitamins (%)	4.20	4.20	4.20	4.20
ED (kcal/kg)	3225	3215	3205	3200
CP (g/kg)	226	207	186	171
Lysine	11.9	11.9	11.9	11.8
Methionine + cystine (g/kg)	7.5	7.2	7.1	7.1
Tryptophan (g/kg)	3.0	2.7	2.3	2.1

Source: [2,4]

CONCLUSIONS

In pigs, the nutritional protein value of feed (like the protein requirement) may be best expressed through crude protein (CP), crude essential aminoacids and digestible essential aminoacids.

The availability concerns only the aminoacids that may represent limited factors within a certain diet; lysine plays a preponderant role due to

its strictly indispensable character, and also due to its reduced concentration in feed (especially cereals), and especially due to the fact that the amino groups are susceptible of interfering with glucides and lipids.

By using increasing amounts of industrial lysine (0.2-0.42-0.59), we may save the soybean grit as the main lysine supplier, but the threonine and methionine + cystine appear as secondary limiting factors.

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