Acta Univ. Sapientiae, Alimentaria, **6** (2013) 35–44

The relation between quality and quantity with respect to quality parameters of Hungarian field crops

J. Csapó[1]
email: csapojanos@sapientia.siculorum.ro,
csapo.janos@gmail.hu

Z. Győri[2]
email: gyori.zoltan@gtk.szie.hu

[1]Sapientia – Hungarian University of Transylvania,
Faculty of Technical and Social Sciences,
Department of Food Science
Piaţa Libertăţii 1, 530104 Miercurea Ciuc, Romania

[2]Szent István University,
Institute of Regional Economics and Rural Development,
H-2100 Gödöllő, Páter Károly Street 1, Hungary

Abstract. The crude protein content, amino acid content, crude protein amino acid composition and biological value of various basic materials for livestock feeds (wheat, barley, maize, oat, sorghum seeds, soybean, sunflower meal, rapeseed meal and fish meal) were determined. It was established that the glutamic acid and lysine content of crude protein can be estimated on the basis of crude protein content alone. It was verified by means of regression equations that the quantity of amino acids rose with increase in crude protein content. On the examination of protein amino acid composition in relation to crude protein content, it was ascertained that as crude protein content increased, the quantities of the non-essential amino acids also raised, while those of the essential amino acids decreased.

Keywords and phrases: crude protein content, amino acid composition, essential amino acids, biological value, barley, wheat, corn, soybean.

1 Introduction

For the monogastric animals, the fodder stuff mix is to be prepared on the basis of precise calculation based on amino acid analysis, and to be supplemented with synthetic amino acids. Nowadays, the amino acid analysis is rather expensive; it costs 60-70 euros depending on laboratories. In the case of feeding stuff mixes, the amino acid analysis is essential for the purpose of quality control or interventions during production. What is the situation with the raw materials? Is there any way to estimate the amino acid composition of the different feeding stuff raw materials, the amount and proportions of the essential and limiting amino acids; is it possible to omit the long-lasting and expensive amino acid analysis? Is it possible to estimate the amino acid composition of the feeding stuff raw material on the basis of its crude protein content, and if so, with what certainty? Is there any relationship between the crude protein content and amino acid composition of the feeding stuff raw material, as well as between the crude protein content of the feeding stuff raw material and amino acid composition of the feeding stuff protein? In order to find an answer to these questions, we collected the crude protein content and amino acid composition of various feeding stuff raw materials as well as amino acid composition of feeding stuff protein for several years retrospectively at the Department of Chemistry and Biochemistry of the Faculty of Animal Science, Kaposvár University, and tried to find out by computer evaluation whether it is possible to estimate the amino acid composition on the basis of the crude protein content, and if so, with what certainty.

According to investigations of *Michael et al.*, (1961); *Schiller & Oslage*, (1970); and *Schipper*, (1975), with increasing crude protein content in the corn seeds, the proportion of the different proteins changes, which is ultimately the base of the change of the amino acid composition. The change in protein composition with increasing crude protein content is especially striking in the case of wheat and barley as well as of rye, while oats and maize respond to increasing nitrogen fertilizer portions much less (*Schiller*, 1971; *Hoffmann et al.*, 1975; *Jahn-Deesbach*, 1981). *Győri & Bocz*, (1982) and *Bocz & Pepó* (1984) established that in the case of the wheat variety Jubilejnaja-50 the protein content of the wheat grain increases and changes the protein composition due to fertilizing. The amount of the albumin increases, that of the globulin decreases and the high-molecular gluten proteins accumulate.

According to *Kiss et al.* (1985), nitrogen fertilizer applied late increases mainly the reserve proteins of the grain but also changes the amount and proportion of the individual protein fractions. Experiments of *Sonntag & Michael*

(1973) proved that all the factors that considerably increase the amount of the crude protein in the grain will result in a relative decrease of the biologically valuable components. On the basis of his experiments with barley, *Eppendorfer* (1975) established that within the crude protein content the decrease of the sulphur amino acids is considerably lower in the case of enhanced nitrogen fertilizing if the fertilizer is supplemented with sulphur.

Vincze & *Szüts* (1978) examined the change of the protein content and amino acid composition of wheat grain, and found the biological value of the maize protein in the case of nitrogen fertilizer portion of 150-200 kg/ha to be the highest.

Jahn-Deesbach & *Schipper* (1982) established that the crude protein content of barley can reach 16-18%, in extreme cases even 20%. According to their examinations, with increasing nitrogen fertilizer portions, the proline, glutamic acid and phenylalanine content of the barley protein increase, the tyrosine, cystine, methionine and isoleucine content do not change significantly, while all the other amino acids decrease.

Németh (1983) established that the crude protein content of maize was increased by the nitrogen to a smaller extent than that of the wheat. Wheat protein contains few lysine and methionine that further increase due to nitrogen fertilizing.

Whitacre (1985), *Jensen* (1986), *Monsoto* (1986) and *Ivery* (1986) elaborated a computer programme for composing feeding stuff portions on the basis of amino acid composition. They established that although the determination of the composition of the critical amino acid cannot replace the regression equations, this method still gives a better result than if amino acid results were taken only from the tables.

Most of the authors agree that due to increasing nitrogen fertilizer portions the crude protein content of the cereal grains increases, the amount and proportions of the protein fractions in the grain changes, which finally results in differences in the amino acid composition. It appears that this change in the case of wheat, barley and oats is much more expressed than in the case of maize. It appears to be proven that the increase of the crude protein content results in a decrease of the more valuable components, thus, the degradation of the biological value of the protein; this is, however, unambiguously proven if other requirements of the plant are not satisfied adequately when fertilizing with increased portion of nitrogen fertilizer.

2 Materials and methods

Experimental materials. During our experiments, we examined the crude protein content and amino acid composition of 154 wheats, 172 barleys, 210 maizes, 42 oats, 41 seed sorghums, 118 soya, 102 sunflower grits and 21 rape grits. For the examined materials, the crude protein content varied between the following extreme values: wheat: 10.5-16.2%, maize: 7.9-11.0%, seed sorghum: 10.1-13.5%, sunflower grits: 35.8-45.5%, barley: 7.9-13.7%, oats: 9.8-13.7%, soya: 39.1-51.5% and rape grits: 32.1-39.1%.

Chemical examination of the samples. Determination of dry-matter and crude protein content of samples was carried out according to the feeding stuff examination standard No. MSZ 6830, whereas amino acid composition according to as described in the works of *Csapó* & *Csapóné* (1985) as well as *Csapó et al.*, (1986).

Mathematical analysis of the results. We tried to establish relationships between crude protein and amino acid composition as well as the crude protein and amino acid composition of the feeding stuff protein by bivariate regression relationship; thus, we expressed the relationship between the crude protein and amino acid composition by the regression equation $Y = a + bx$.

3 Results and discussion

Results of the experiments. Parameters of the bivariate linear regression equation between the amino acid composition and crude protein content of barley and barley protein are shown in *Table 1*; the change in amino acid composition as a function of the crude protein content is shown in *Table 2.* For the rest of the examined feeding stuffs, the numerical results cannot be presented due to lack of space.

Table 1: Parameters of the bivariate linear regression equation between the amino acid composition and crude protein content of barley and barley protein ($n = 62$; examined crude protein range: 7.9-13.7%, dispersion of the crude protein = 1.8564)

1/1 Crude protein and amino acid content of the barley

Parameters	Amino acid								
	Thr	Cys	Val	Met	Ile	Tyr	Lys	Glu	Pro
Regression coefficient	0.0244	0.0149	0.0378	0.0080	0.0194	0.0259	0.0205	0.3145	0.1717
Regression constant	0.1176	-0.0084	0.0480	0.0453	0.1511	0.1787	0.1780	-0.6441	-0.5896
Correlation coefficient	0.5907	0.2895	0.4849	0.0970	0.4541	0.6747	0.2835	0.8432	0.7376
Probability level(P)	0.1%	5%	0.1%	-	0.1%	0.1%	5%	0.1%	0.1%
1/2 Crude protein and amino acid composition of the barley protein									
Regression coefficient	-0.0993	0.0044	-0.0514	-0.0182	-0.1068	-0.0517	-0.1410	0.7209	0.5096
Regression constant	4.7560	1.4173	4.9828	1.4431	4.5821	3.9513	5.3374	17.7746	6.3033
Correlation coefficient	0.2158	0.00054	0.0632	0.0067	0.2681	0.1165	0.2276	0.3906	0.2510
Probability level(P)	10%		-	-	5%	-	10%	1%	5%

In the case of the barley for Thr, Val, Ile, Tyr, Glu and Pro at $P = 0.1\%$ level, for Cys, Lys at $P = 5\%$ level, whereas for Met even at $P = 10\%$ level, there is no positive correlation between the crude protein content and amino acid composition. Between the crude protein content of the barley and the amino acid composition of the barley protein for Glu at $P = 1\%$, for Pro at $P = 5\%$ level, there is a positive correlation, while for Ile at $P = 5\%$, for Lys and Thr at $P = 10\%$ level, a negative correlation. On the basis of the regression coefficient value, it appears that with increasing crude protein content – in a significantly not provable way – beyond the above, decreases Val, Met and Tyr content of the barley protein.

Table 2: Amino acid composition of the barley as a function of the crude protein content (gram amino acid/100 gram barley)

Crude	Amino acid								
protein %	Thr	Cys	Val	Met	Ile	Tyr	Lys	Glu	Pro
7.0	0.289	0.097	0.313	0.102	0.287	0.260	0.324	1.557	0.612
7.5	0.301	0.105	0.332	0.106	0.297	0.273	0.334	1.715	0.698
8.0	0.313	0.112	0.351	0.110	0.307	0.286	0.344	1.872	0.784
8.5	0.325	0.120	0.370	0.114	0.316	0.299	0.355	2.029	0.780
9.0	0.337	0.127	0.388	0.118	0.326	0.312	0.365	2.186	0.956
9.5	0.350	0.135	0.407	0.122	0.336	0.325	0.375	2.344	1.041
10.0	0.362	0.142	0.426	0.126	0.345	0.338	0.385	2.501	1.127
10.5	0.374	0.150	0.445	0.130	0.355	0.351	0.395	2.658	1.213
11.0	0.386	0.157	0.464	0.134	0.365	0.364	0.406	2.815	1.299
11.5	0.398	0.165	0.483	0.138	0.375	0.377	0.416	2.973	1.385
12.0	0.411	0.172	0502	0.142	0.384	0.390	0.426	3.130	1.471
12.5	0.423	0.179	0.521	0.146	0.394	0.402	0.436	3.287	1.557
13.0	0.435	0.187	0.540	0.150	0.404	0.415	0.446	3.444	1.642
13.5	0.447	0.194	0.559	0.154	0.413	0.428	0.457	3.601	1.728
14.0	0.460	0.202	0.578	0.158	0.423	0.441	0.467	3.759	1.814
14.5	0.472	0.209	0.597	0.162	0.433	0.454	0.477	3.916	1.900
15.0	0.484	0.217	0.615	0.166	0.442	0.467	0.487	4.073	1.986
15.5	0.496	0.224	0.634	0.170	0.452	0.480	0.498	4.231	2.071
16.0	0.508	0.232	0.653	0.174	0.462	0.493	0.508	4.388	2.157

Summarizing the results obtained for the other examined materials, it can be said that the percentage amino acid composition of the feeding stuff, that is, the amount of amino acids present in 100 g feeding stuff raw material, can be estimated on the basis of the crude protein content with appropriate accuracy for most of the examined amino acids. Reliability of the estimation is the highest for glutamic acid, for tyrosine (at $P = 0.1\%$ reliability level), followed by valine, threonine and lysine (P = 1%), and cystine (P = 5%), isoleucine (P = 10%), and finally by methionine, where no estimation can be carried out even at a P = 10% level. It can be clearly stated that, on the basis of crude protein content, in the case of most of the feeding stuff raw materials, all amino acids, which are important regarding feeding – with the exception of methionine –, can be estimated with an accuracy necessary for the production of feeding stuff mixes.

The above statement is not true to amino acids present in the feeding stuff protein. On the basis of the crude protein content, only glutamic acid and lysine content of the feeding stuff protein can be estimated at a P = 10% probability level; the amount of the rest of the amino acids cannot be estimated.

Based on the regression coefficient, we established that in the feeding stuff each examined amino acid increases along with the crude protein content. Examining the amount of the amino acids in the percentage of the protein, it can be established that glutamic acid and proline increased in the function of the crude protein content in the case of all the other feeding stuff raw materials, while the other amino acids – in most cases – decreased. It can be concluded that with increasing crude protein content the amount of non-essential amino acids increases and that of essential amino acids decreases in the feeding stuff protein.

Evaluating our results in the light of the literature, we come to the following conclusions: similarly to the results of *Vincze* & *Szüts* (1978), we experienced the increase of the Glu and Pro content of the maize protein and the decrease of its Lys content with increasing crude protein content. In the case of wheat, we established the increase of all the amino acids with increasing crude protein content in contrast with the above authors, who obtained maximums and minimums due to different nitrogen doses.

Similarly to the conclusion of *Jahn-Deesbach* & *Schipper* (1982), we obtained a rapid increase of Glu and Pro in the case of the barley with increasing crude protein content. Similar results were obtained regarding the change of the amino acid composition of the barley protein. Glu and Pro increased, while the other amino acids did not change considerably, or decreased due to increasing crude protein content in the barley protein.

Németh (1983) observed the decrease of Lys and Met content of the wheat protein, as well as the amount of most of the amino acids of the maize protein due to a nitrogen dose. In our experiments, the Lys content of the maize protein decreased, while the Met content increased with increasing crude protein content.

References

[1] E. Bocz, J. Pepó, A műtrágyázás és az öntözés hatása az őszi búzafajták minőségére. (The effect of fertilization and irrigation on the quality of wheat varieties). *Növénytermelés*, 33. (1984) 5. 407–417.

[2] J. Csapó, Zs. Csapóné Kiss, Új ioncserés oszlopkromatográfiás módszerek élelmiszerek és takarmányok analízisében. (New ion-exchange column chromatographic methods in the food and feed analysis). MTA Kémiai Tudományok Osztálya, Budapest, Erdey László díjas pályamunka. (1985), p. 139.

[3] J. Csapó, I. Tóth-Pósfai, Zs. Csapóné Kiss, Optimization of hydrolysis at determination of amino acids content in food and feed product. *Acta Alimentaria*, 15. (1986) 3–21.

[4] W. N. Eppendorfer, Effects of fertilizers on quality and national value of grain protein. *Fertilizer use and protein production.* Der Bund AC., Bern. Switzerland, (1975) 249–263.

[5] Z. Győri, E. Bocz, Az öntözés és trágyázás hatása Jubilejnaja 50 búzafajta termék minőségére. (Effect of irrigation and fertilization on the quality of Jubilejnaja 50 wheat species). *Növénytermelés*, 31. (1982) 3. 217–225.

[6] P. Hoffmann, M. Tanner, K. Hoeser, G. Averdunk, Untersuchungen über Einfluss einer Sticksoff-Spätdüngung auf Ertrag, Protein- und Aminosauregehalt bei verschiedenen. *Weizensorton. Landwirtsch. Forschung*, Frankfurt. 28. (1975) 1–23.

[7] F. J. Ivey, Optimizing ingredient utilization. *Proceedings of the 1986 Animal Nutrition Council Symposia.* (1986) 1–13.

[8] W. Jahn-Deesbach, Untersucheungen Über den Einfluss von Klimafaktoren auf Ertrag und Qualität von Weizen (Klimakammerversuche). *Getreide, Mehl u. Brot*, Frankfurt. 35. (1981) 281–286.

[9] W. Jahn-Deesbach, A. Schipper, Über die Anderungen der Aminosäuren-Gehalte in Gerete bei steigerden Rohproteingehalten. *Landwirtsch. Forschung*, Frankfurt. (1982) 3–4.

[10] L. S. Jensen, Low protein diets and amino acid supplementation for broilers. *Degussa Technicol Symposium*, Indianapolis, Indiana, 1986 May 6. 4–15.

[11] E. Kiss, K. Debreczeni, J. Pethes, A különböző időben adagolt nitrogén fejtrágya beépülése az őszi búza szemtermésébe. (Effect of different times nitrogen fertilization for built in into the seed of winter wheat). *Búzatermesztési kísérletek 1970-1980.* Akad. Kiad. Budapest, (1985) 228–234.

[12] G. Michael, B. Blume, M. Faust, Die Eiweissqualität von Körnern verschiedener Getreidearten in Abhängigkeit von Stickstoffversorgung und Entiwcklungszustand. *Z. Pflanzenerähr, Düng, Bodenkde.*, Frankfurt, 92. (1961) 106–116.

[13] I. Németh, A búza és kukorica nyersfehérje- és aminosavtartalmának alakulása a nitrogén-, foszfor- és káliumtrágyázás függvényében. Effect of nitrogen, phosphorous and potassium fertilization for the crude protein content and amino acid composition of wheat and maize). *Növénytermelés*, Budapest. 32. (1983) 1. 37–45.

[14] Nutrition Update, Amino acid in feed ingredients and their predictability. *Monsoto Co-, Animal Scienses Division*, 800 N. Lindbergh Blvd., St. Louis, USA Mo. 633167. (1986).

[15] K. Schiller, H. J. Oslage, Untersuchungen über die Variabilität von Futtergerstenprotein. 1. Mitteilung: Über den Einfluss ökologischer Faktoren auf den Proteingehalt in Gersten und dessen ernährungsphysiologische Qualität. *Landwirtsch. Forschung*, Frankfurt. 23. (1970). 317–332.

[16] K. Schiller, Untersuchungen über die Variabilität von Futtergerstenprotein. 2. Mitteilung: Über den Einfluss ökologischer Faktoren auf die Eiweissarten in Protein von gerstencaryopsen. *Lanwirtch. Forschung*, Frankfurt. 24. (1971) 15–33.

[17] A. Schipper, Quantitate and Qualität der Proteine in Getreide Ergebn. Landw. Forschung, Justus-Liebig-Universität, Giessen VIII. (1975) 50–58.

[18] Chr. Sonntag, G. Michael, Einfluss einer späten Stickstoffdüngung auf Eiweissgehalt und Eiweisszuzammensetzung von Körner Konventioneller und Lysinreicher Formen von Mais und Gerste. *Z. Acker-u. Pflanzenbau*, Berlin. 138. (1973) 116–128.

[19] J. Sváb, Biometriai módszerek a kutatásban. (Biometrical methods in research). Mezőgazdasági Kiadó, Budapest. 1973.

[20] M. F. Whitacre, Amino acid profiles and regression equations of major feed ingredients. *Degussa Technical Symposium*, Fresno, CA, 1985. March 13. 34–57.

[21] L. Vincze, G. Szüts, A búza- és kukoricafehérje aminosavtartalom alapján számított biológiai értékének alakulása a nitrogén műtrágyaadag változásának függvényében. (Biological value of the corn and wheat protein calculated from amino acid composition influenced by the dose of nitrogen fertilizer). *XX. Georgikon Napok*, Keszthely. 1978. 380–397.