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Evaluation the nutrient composition of extracted sunflower meal samples, determined with wet chemistry and near infrared spectroscopy

Különböző extrahált napraforgódarák táplálóanyag-tartalmának értékelése laboratóriumi módszerekkel és NIR készülékkel

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ABSTRACT

Twenty extracted sunflower meal (SFM) samples were collected and analysed with classical laboratory methods and near infrared spectroscopy (NIRS). From the results, the variance of the nutrients, the accuracy of NIRS prediction and the interaction of the different nutrients have been evaluated. The results showed that NIRS provides high accuracy for crude protein, amino acids, fibre fractions and total phosphorus. The reliability for crude fat, crude ash and sugar predictions was however lower. The relationship between the measured and estimated amino acid contents was significant in all cases with high correlation coefficients. The crude protein content of the SFM samples showed a positive correlation with the crude ash, phosphorous and sugar contents, and a negative correlation with all fibre fractions. According to our results, the amino acid composition of the sunflower meal protein is not constant. The ratio of methionine and histidine HIS is higher, while that of cysteine, tyrosine, arginine, isoleucine, leucine, valine and phenylalanine is lower when the protein content of SFM increase.

Keywords: extracted sunflower meal, chemical composition; NIRS; nutrient correlations, protein quality

ÖSSZEFOGLALÁS

Húsz extrahált napraforgódara mintát gyűjtöttünk és elemeztünk klasszikus laboratóriumi módszerekkel és közeli infravörös spektroszkópiával (NIRS). A mérési eredményekből meghatároztuk a táplálóanyagok varianciáját, a NIR készülék becslési pontosságát és a különböző táplálóanyagok kölcsönhatását. Az eredmények azt mutatták, hogy a NIR készülék nagy pontosságot ad a nyersfehérje, az aminosavak, a rostfrakciók és az összes foszfor tekintetében. A nyers zsír, nyershamu és cukor esetében a NIR becslés pontossága azonban kisebb volt. A mért és a becsült aminosavtartalom közötti kapcsolat minden esetben szignifikáns volt, magas korrelációs együttható mellett. A minták nyersfehérje-tartalma pozitív korrelációt mutatott a nyershamu-, foszfor- és cukortartalommal, és negatív korrelációt az összes rostfrakcióval. Eredményeink szerint a napraforgódara fehérje aminosav-összetétele nem állandó. A fehérjén belül a metionin és a hisztidin aránya magasabb, míg a cisztein, tirozin, arginin, izoleucin, leucin, valin és fenilalanin aránya alacsonyabb a napraforgódara fehérjetartalmának növekedésekor.

Kulcsszavak: extrahált napraforgódara, kémiai összetétel, NIR, táplálóanyag korreláció, fehérje minőség

INTRODUCTION

One of the greatest challenges of the near future is to provide the world's population with sufficient food in a sustainable way. Livestock, especially the poultry sector plays a key role in this, since poultry meat consumption increasing constantly worldwide. Poultry meat production is the most efficient transformation of dietary protein to animal protein, but facing several challenges due to climatic change, increasing feedstuff and energy prices and the uncertainty of transportation of the feedstuffs among continents. The European countries are especially concerned because of the insufficient protein resources and the almost 30 million tons of annual soybean and soybean meal import (De La Hamaide et al., 2021). The gap between the locally available protein sources and the demand is expected to widen in the future, which force the feed industry to replace at least partly soybean with alternative feedstuffs. There are a number of known protein sources that could be suitable substitutes for soybean (Ravindran, 2013). Among the potential solutions the oil industry by-product, extracted sunflower meal (SFM) could be of particular interest. The chemical composition of the seed depends primarily on variety, cultivation, fertilization and soil (Ravindran and Blair, 1992). The extent of dehulling during solvent extraction is the most important factor that determines the protein and fibre contents of the extracted meal (Senkoylu and Dale, 2019). Hull removal from the oil-type sunflower seeds is not complete because of the binding of the hulls to the kernel. Furthermore, in some oil industry plants certain parts of the hulls are added back to the meal. The heat treatment during the pressing and the solvent extraction phases in the oil industry could also have impacts on the nutritive value of the by-product (Van Krimpen et al., 2013). Protein digestibility decrease and amino acids, mostly the first limiting amino acid of SFM, lysine can damage if over-processing happens (Zhang et al., 1994). So, several technologies exist that provide SFM with different nutrient contents (Senkoylu and Dale, 2019). The European extracted sunflower meals contain on average 33.55% protein, 1.79% crude fat, 17.67% crude fibre, 31.39% NDF, 5.47% sugar and 1.06% phosphorous of which 91% is in phytic bounds (Evonik, 2017).

Unlike to most protein sources, legume seeds or rapeseed products, SFM does not contain such anti-nutritional factors that could influence its incorporation rate. Although the raw SFM contains chlorogenic and quininic acids with trypsin and lipase inhibiting activities, these compounds are heat sensitive, partly destroyed during the extraction procedure and do not affect negatively the production traits (Treviño et al., 1998).

The main limitations of SFM are its high fibre, low energy and low lysine content, but on diet level, the energy and lysine can be compensated with crystalline lysine and fat supplementation. The structural fibre of means constraint, however, the optimum dietary fiber inclusion level for a different type of poultry is not well characterized.

According to the research data, depending on the fibre content of SFM, it could be used at even 20-50% in broiler diets, and 10-38% in pullet and layer diets contents (Senkoylu and Dale, 2019). In waterflow feeds, SFM could replace soybean meal even at 100% without adversely affecting the growth rate or feed conversion of ducks or geese (Senkoylu and Akyurek, 1992; Vetési et al., 1998). Currently, sunflower meal is used mostly in the layer and in the grower and finisher diets of meat-type birds at about a 5-10% inclusion rate. This feeding ratio can certainly be increased when high-quality SFM with lower fibre contents is used and if more detailed information is available on the fibre tolerance of birds and the nutrient content of the by-products.

Near infrared spectroscopy (NIRS) is used widely in feedstuff evaluation worldwide. Several companies offer calibrations to establish the chemical composition of the feed ingredients just after a few seconds. However, the accuracy of this prediction is changing according to the ingredients and the nutrient under investigation. In the frame of this research, our main goal was to determine the accuracy of NIRS evaluation of randomly collected SFM samples. Besides that, the variation of the different nutrients and the correlations between them was also analysed. There is limited information how the protein content of SFM affects its amino acid composition. It is crucial since the constant amino acid profile of the feedstuff proteins is used to calculate amino acid contents from the crude protein. In the case of SFM, not only the genotype and fertilisation but also the rate of dehulling modify the amino acid composition. Fewer means more amino acids from the concentrated protein fractions of the seed and less from the aleurone layer (Green and Kiener, 1989), which means differences both in the amino acid composition and amino acid digestibilities (Villamide and San Juan, 1998). Our aim was also to assess the protein quality of SFM in relation to the amino acid requirements of broiler chickens and compared with those of wheat, corn and soybean meal.

MATERIALS AND METHODS

During our study, a representative 1 kg extracted sunflower meal was collected from the domestic market. A total of 20 different samples, representing the sunflower meals, available in the country were collected according to the main rules of representative feed sampling. The sampling was carried out on the basis of feed manufacturing companies, in the different regions of Hungary. The collection has been done both from silos and horizontal storage places. The NIR measurements were performed at the plant of Agrofeed Ltd. in Szalkszentmárton, Hungary, using a Foss NIRS BS 2500 equipment (FOSS Analytical A6S, Hillerod, Denmark) with appropriate calibration for sunflower meals followed by measurements of the same nutrient categories as used in the NIR estimation, using standard methods at the Laboratory of Food and Feed Analysis of the Institute of Physiology and Nutrition, Hungarian University of Agriculture and Life Sciences, Georgikon Campus, Hungary. In addition to the proximate categories (crude fibre, crude fat, crude protein, crude ash) the ADF, NDF (ISO 6865:2001), total sugars (Luff Schoorl method, EG 152.2009), total phosphorus (ISO 6491:1998), phytin phosphorus (Megazyme, K-Phyt 5/17), amino acids (Ingos Amino Acid Analyzer AAA 400; ISO 13903:2005) and gross energy (GE; IKA C6000, IKA-Werke GmbH & Co. KG Janke-Kunkel Str. 10. 79219 Staufen, Germany) contents of SFM samples have also been determined. The average, the minimum and maximum levels and the standard deviation of the nutrients have been calculated. The variance of the nutrients was evaluated by the coefficient of variation (CV). A paired sample t-test was performed for predicted and laboratory values to ensure that there is no significant difference between their means at a 95% confidence interval. The interactions between the different nutrients and between the crude protein and individual amino acids of SFM were evaluated by Pearson's correlation. Protein quality of SFM, extracted soybean meal (SBM), corn and wheat were assessed with the chemical score (CS) and essential amino acid index (EAAI) calculations. In the case of CS, the essential amino acid contents of feedstuff proteins were divided with those of the requirements of the broiler chickens. The chicken requirements were expressed as the amino acid composition of the grower's diet on the same protein basis. EAAI was calculated as the geometric mean of AA ratios of the CS computation. The amino acid composition of wheat, corn and soybean meal proteins was based on the database of the European raw material crop report of Evonik Ltd. (Evonik, 2017). All statistical analysis was carried out with the SPSS 23.0 statistical software package.

RESULTS

Nutrient content of SFM samples

The data of Table 1 shows that the tested samples contained on average 38.49% crude protein, 1.08% crude fat and 16.57% crude fibre in the range of 34.32 to 46.50%; 0.61 to 1.78% and 6.96 to 23.02% respectively. In both the measured and NIRS predicted results the highest variability (CV%) was observed for crude fat, crude fibre, ADF and NDF. The lower variance was found for the crude protein, sugar and phosphorous. Gross energy was the parameter with the lowest variability. All the CV values were higher in the measured parameters compared with the NIR predictions. Except for GE, the relationship between the predicted and measured nutrient contents was significant. The "r" values showed high accuracy for crude protein, for the different fibre fractions and phosphorous. Lower correlation coefficients for crude fat, dry matter and phytic phosphorous means lower accuracy of NIRS.

Table 1. Nutrient content of extracted sunflower meal samples determined by NIRS and wet-chemistry

n = 20	Dry matter	Crude protein	Crude fat	Crude fibre	Crude ash	ADF [4]	NDF [5]	Sugar	P [6]	Phytic-P [7]	GE [8]
NIRS [1] average	91.42	41.22	1.81	17.41	7.01	20.36	28.19	5.70	1.19	1.02	17.58
minimum	90.03	37.28	1.30	10.50	6.10	12.40	18.10	5.10	1.03	0.87	17.36
maximum	92.65	48.10	2.40	21.00	8.10	24.40	33.80	6.60	1.45	1.23	18.14
St. dev. [2]	0.74	3.30	0.31	3.57	0.61	3.80	5.54	0.51	0.13	0.11	0.17
CV% [3]	0.81	8.02	17.00	20.53	8.67	18.67	19.66	9.02	10.59	10.59	0.95
wet chemistry average	92.23	38.49	1.08	16.57	7.62	20.25	28.38	6.04	1.39	1.00	17.94
minimum	91.09	34.32	0.61	6.96	6.70	10.42	16.09	4.59	1.21	0.83	17.02
maximum	92.79	46.50	1.78	23.02	8.84	26.20	38.29	7.38	1.73	1.28	18.23
St. dev.	0.35	4.52	0.26	5.51	0.69	5.25	6.84	0.81	0.18	0.14	2.86
CV%	0.38	11.75	23.53	33.25	9.02	25.92	24.09	13.47	12.85	13.54	1.60
Paired-samples t-test											
r values	0.757	0.965	0.457	0.935	0.849	0.934	0.904	0.735	0.911	0.797	0.282
p values	0.000	0.000	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.229

[1] Near infrared spectroscopy; [2] standard deviation; [3] coefficient of variation; [4] acid detergent fiber; [5] neutral detergent fiber; [6] phosphorus; [7] phytic-phosphorus; [8] gross energy

The measured amino acid content of the SFM samples showed higher variance and the extent of variance was amino acid-dependent (Table 2). Among the essential amino acids, the variance of methionine, lysine, threonine and histidine was the highest, while cysteine, tyrosine, arginine, leucine, isoleucine and valine had less variability. The variance of the NIRS results was lower and more balanced for all amino acids (CV of 7.74 to 9.53%). In spite of the differences in the coefficients of variation, the accuracy of NIRS prediction was in all cases significant with high r values.

Several significant interactions between the different nutrients were found (Table 3). As expected, a negative correlation exists between the crude protein content and the different fibre fractions. On the other hand, sugar, phosphorous and phytic phosphorous correlated positively with the crude protein content of the sunflower meals.

Since extracted SFM is an important protein source in animal nutrition, the correlation between the essential amino acids and the constancy in the amino acid composition of the sunflower protein has also been evaluated. As can be seen from the data in Table 4, MET and HIS showed the most significant interactions with the other essential amino acids. Methionine showed a negative correlation with ARG, LEU, VAL and PHE and a positive relationship with HIS. The change in HIS in the sunflower protein had positive correlation with THR and negative correlation with CYS, TYR, ARG, LEU and ILE.

The change in the crude protein content of SFM did not influence the relative LYS and THR content. However, the relative MET and HIS contents increased when the protein was higher. Significant negative correlation was found between the relative ratio of the other essential amino acids and crude protein.

Comparing the essential amino acid composition of sunflower meal protein with those of other feedstuffs, it contains less lysine and more sulphuric amino acids and arginine than SBM (Figure 1). The other essential amino acid contents of SFM protein are close to those of corn and wheat, except arginine, of which the ratio is almost two times higher in SFM and leucine, which is the dominant essential amino acid in corn protein.

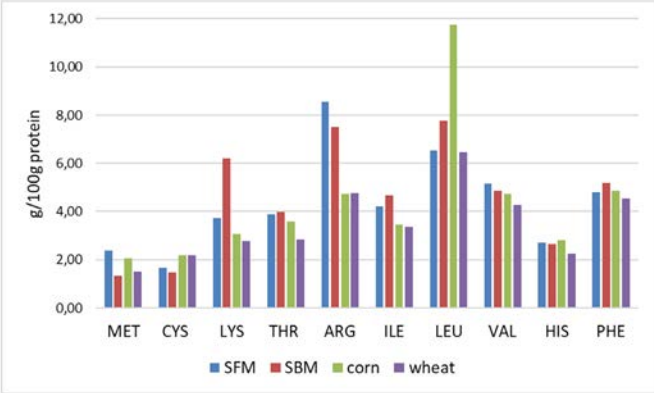

Figure 1. The amino acid composition of sunflower meal, soybean meal, corn and wheat proteins

The relative amino acid contents of the different protein sources have also been compared with the amino acid requirements of broiler chickens (Aviagen, 2018) (Figure 2). The closer are the essential amino acid ratios to the requirement (100%, red line), the more balanced the protein, meaning fewer deficiencies and surpluses. The figure shows that the arginine content in both extracted meals is about 60-80% higher than the requirement of the chickens. The same is true for the leucine content of corn. All the other amino acid ratios are around 100% or below. The figure also shows that the lysine ratio of soybean meal and the methionine ratio of sunflower meal proteins both cover the requirements of the chickens.

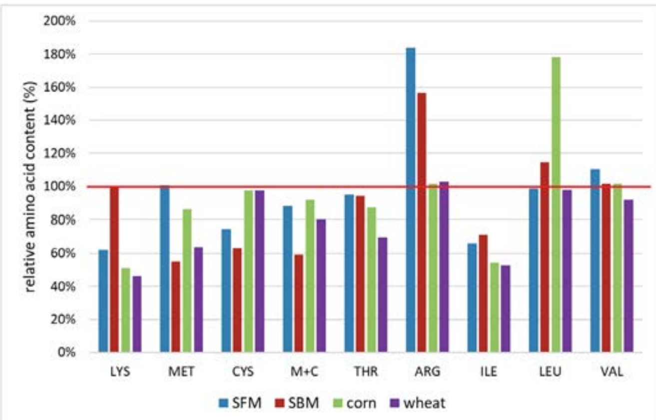

Figure 2. The ratio of amino acid contents of sunflower meal, soybean meal, corn and wheat proteins in comparison with the requirements of broiler chickens

From the amino acid ratios of Figure 2, the essential amino acid index of the protein sources was also calculated (Figure 3).

Table 2. The amino acid composition of extracted sunflower meal samples determined by NIR and wet-chemistry

n = 20	MET[4]	CYS	LYS	THR	TYR	ARG	ILE	LEU	VAL	HIS	PHE	GLY	SER	PRO	ALA	ASP	GLU
NIRS [1] average	0.93	0.65	1.46	1.50	0.52	3.34	1.66	2.58	2.01	0.98	1.84	2.44	1.72	1.75	1.74	3.65	7.75
min.	0.86	0.60	1.34	1.36	0.47	3.04	1.51	2.34	1.83	0.89	1.70	2.25	1.56	1.58	1.58	3.32	7.11
max.	1.09	0.76	1.71	1.75	0.64	4.02	1.98	3.04	2.38	1.16	2.17	2.85	2.02	2.06	2.04	4.32	9.28
St. dev. [2]	0.08	0.05	0.12	0.12	0.05	0.30	0.14	0.22	0.17	0.09	0.14	0.19	0.15	0.14	0.15	0.32	0.67
CV% [3]	8.08	8.09	8.16	7.92	9.53	8.84	8.64	8.35	8.54	8.85	7.80	7.74	8.44	8.26	8.33	8.63	8.68
Wet chemistry average	0.92	0.64	1.43	1.50	1.01	3.29	1.62	2.51	1.98	1.05	1.84	2.35	1.73	1.76	1.74	3.63	8.03
min.	0.79	0.57	1.27	1.31	0.83	2.98	1.43	2.19	1.75	0.90	1.67	2.07	1.52	1.49	1.52	3.29	7.14
max.	1.19	0.76	1.78	1.85	1.17	3.86	1.93	2.93	2.27	1.38	2.18	2.83	2.13	2.20	2.09	4.39	9.98
St. dev	0.14	0.06	0.18	0.20	0.10	0.32	0.17	0.24	0.18	0.18	0.18	0.29	0.23	0.26	0.21	0.41	1.10
CV%	15.07	9.07	12.25	13.10	9.72	9.71	10.33	9.58	8.84	17.01	9.59	12.33	13.22	14.69	12.06	11.36	13.71
									Paired-samples t-test								
r values	*0.973*	*0.935*	*0.970*	*0.955*	*0.827*	*0.905*	*0.917*	*0.960*	*0.891*	*0.971*	*0.925*	*0.942*	*0.967*	*0.935*	*0.929*	*0.962*	*0.950*
p values	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

[1] Near infrared spectroscopy; [2] standard deviation; [3] coefficient of variation; [4] methionine, cystine, lysine, threonine, tyrosine, arginine, isoleucine, leucine, valine, histidine, phenylalanine, glycine, serine, proline, alanine, aspartic acid, glutamic acid.

Table 3. Correlation between the different nutrients of extracted sunflower meal samples

		Crude protein	Crude fat	Crude fiber	Crude ash	ADF [1]	NDF [2]	Sugar	P [3]	Phy-P [4]	GE [5]
Crude protein	r-value	1									
	p-value										
Crude fat	r-value	0.338									
	p-value	0.145									
Crude fiber	r-value	-0.984	-0.326								
	p-value	0.000	0.161								
Crude ash	r-value	0.92	0.335	-0.926							
	p-value	0.000	0.149	0.000							
ADF	r-value	-0.988	-0.367	0.984	-0.922						
	p-value	0.000	0.111	0.000	0.000						
NDF	r-value	-0.962	-0.315	0.964	-0.953	0.964					
	p-value	0.000	0.176	0.000	0.000	0.000					
Sugar	r-value	0.698	0.174	-0.706	0.72	-0.645	-0.702				
	p-value	0.001	0.462	0.001	0.000	0.002	0.001				
P	r-value	0.973	0.319	-0.969	0.922	-0.985	-0.959	0.696			
	p-value	0.000	0.170	0.000	0.000	0.000	0.000	0.001			
Phy-P	r-value	0.848	0.332	-0.855	0.847	-0.862	-0.87	0.65	0.895		
	p-value	0.000	0.153	0.000	0.000	0.000	0.000	0.002	0.000		
GE	r-value	0.244	0.06	-0.189	0.138	-0.204	-0.227	0.495	0.266	0.235	
	p-value	0.3	0.801	0.424	0.56	0.387	0.335	0.027	0.256	0.318	

[1] acid detergent fiber; [2] neutral detergent fiber; [3] phosphorus; [4] phytic-phosphorus; [5] gross energy

Table 4. Correlations between the relative amino acid contents (% of protein) and the crude protein content of sunflower meal samples

		[1] MET	CYS	LYS	THR	TYR	ARG	ILE	LEU	VAL	HIS	PHE
MET	r-value	1										
	p-value											
CYS	r-value	-0.07										
	p-value	0.768										
LYS	r-value	0.268	0.071									
	p-value	0.253	0.767									
THR	r-value	0.3	-0.184	0.219								
	p-value	0.198	0.438	0.355								
TYR	r-value	-0.574	0.336	-0.149	-0.375							
	p-value	0.008	0.148	0.53	0.103							
ARG	r-value	-0.576	0.365	-0.42	-0.32	0.462						
	p-value	0.008	0.114	0.066	0.169	0.041						
ILE	r-value	-0.243	0.479	-0.272	-0.442	0.236	0.181					
	p-value	0.301	0.033	0.246	0.051	0.316	0.444					
LEU	r-value	-0.451	0.304	-0.043	-0.29	0.432	0.162	0.576				
	p-value	0.046	0.192	0.859	0.215	0.057	0.495	0.008				
VAL	r-value	-0.766	0.289	-0.487	-0.435	0.59	0.719	0.394	0.536			
	p-value	0.000	0.217	0.029	0.055	0.006	0.000	0.086	0.015			
HIS	r-value	0.697	-0.564	0.357	0.444	-0.594	-0.661	-0.616	-0.603	-0.849		
	p-value	0.001	0.01	0.122	0.05	0.006	0.002	0.004	0.005	0		
PHE	r-value	-0.698	0.276	-0.128	-0.338	0.589	0.74	-0.006	0.403	0.743	-0.581	
	p-value	0.001	0.239	0.592	0.145	0.006	0.000	0.98	0.078	0	0.007	
Crude	r-value	0.62	-0.662	0.176	0.336	-0.518	-0.692	-0.468	-0.683	-0.728	0.849	-0.721
Protein	p-value	0.004	0.001	0.457	0.148	0.019	0.001	0.038	0.001	0.000	0.000	0.000

[1] methionine, cystine, lysine, threonine, tyrosine, arginine, isoleucine, leucine, valine, histidine, phenylalanine

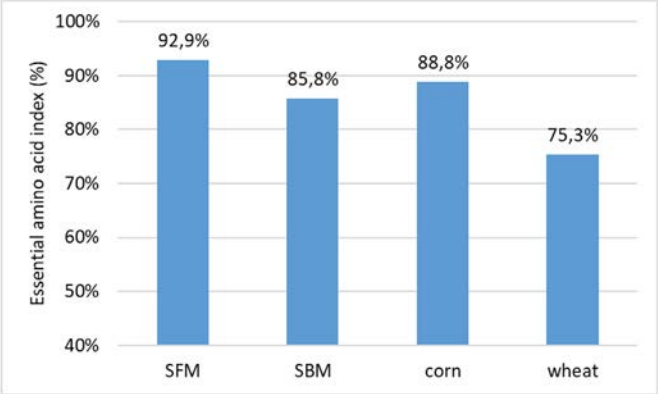

Figure 3. The essential amino acid index of sunflower meal, soybean meal, corn and wheat proteins

This characteristic of the protein takes into account how close the amino acid ratios are to the requirements. From this aspect, the sunflower meal protein is the most balanced.

DISCUSSION

The chemical composition of the measured SFM samples was similar to those published for the Hungarian products in the European raw material crop report by Evonik (Evonik, 2017). The samples, evaluated by wet chemistry contained about 4% more crude protein, 1% less crude fat and 1.5% less crude fibre. These changes in the last few years mean improvement in the quality of the product. The NIRS prediction is accurate for the main nutrient categories, except crude fat and gross energy (GE). The reason for that was the low concentration of fat in the meals, which decrease the accuracy of prediction. The measured GE-s showed higher variance than the predicted values. It was the main difference and the reason for the not significant relationship. However, it does not have big importance, because GE is not used directly in the practical diet formulations and prediction of the metabolizable energy contents. In almost all cases, the variance of the measured parameters was higher than those of the NIRS prediction. It suggests that NIRS probably underestimates the highest and overestimates the lowest values of the measured parameters.

The prediction accuracy of the amino acid contents was in all cases high and the relationship between the two methods was significant. Also, in this case, the variance was higher in the measured category.

In accordance with the literature data (Senkoylu and Dale, 2019) the SFM protein is relatively rich in methionine and arginine but contains less lysine than soybean meal. In the case of the other essential amino acids, SFM protein contains similar or higher concentrations than the wheat and corn proteins.

Comparing the relative amino acid compositions of feedstuff proteins with the amino acid content of the dietary protein for broiler chickens, the first limiting amino acid of SFM is lysine, followed by isoleucine and cysteine. It is in agreement with other findings (Green et al., 1987; Dessouky, 1996). The all-other essential amino acids in SFM are close to the requirements of the chicken. It is the reason, that the essential amino acid index of SFM exceeds those of soybean meal, wheat or maize. This result could have also practical relevance since the price of crystalline amino acids increases with the global feed prices and supplementation of poultry feeds with them is not always competitive. Therefore, SFM can be a reason for using it at least as a partial substitution of soybean.

The negative correlation between the crude protein and the fibre fractions of SFM in our results is well known (Senkoylu and Dale, 2019; Canibe et al., 1999). However, the positive relationship between the protein content and total sugar and phosphorous is a new result, that has not been published yet elsewhere.

The protein amino acid composition of each feedstuff is characteristic of the feed. It is the reason that in the frame of NIRS prediction ingredient specific regression equations are used for calculating the amino acid contents as a function of crude protein and dry matter content. This theory is, however, not always true. It is well known, that special crops, like maize, have been selected for example for increased lysine content. There are such breeds also for SFM (Gerhardt and Miller, 1997). The extraction technology, the process of removing the hulls, pressing, and heating in the oil industry can also modify the protein amino acid composition. We have found several significant correlations between the individual essential amino acids. Methionine and histidine had the most significant interactions with other amino acids. Although these results are based only the evaluations of 20 random samples, it is possible, that such interactions can be true for other SFM samples too. According to our results, the amino acid composition of SFM protein is not constant. If the protein content of the product is increasing, the relative amounts of some amino acids increase or decrease. Change in the protein content has no influence on the ratio of LYS and THR. The relative amount of the two mostly variable amino acids, MET and HIS increases when the protein content goes up. The other essential amino acid ratios have a negative correlation with the crude protein. After further investigations and the establishment of a robust database, the mentioned interaction could be used to modify the SFM-specific regression equation, used for the calculation of their amino acid compositions.

CONCLUSION

Among the nutrients of extracted sunflower meals, their crude fat, crude fibre, ADF and NDF have the highest variance. Since fibre affects the digestibility of starch, fats and proteins, the actual fibre content of the products should be analysed regularly. The accuracy of NIRS prediction is higher for the crude protein, amino acids, fibre fractions and phosphorus. However, the estimation of crude fat, crude ash and sugar contents is less accurate. There is a strong negative correlation between the crude protein and fibre content of sunflower meal. According to the results, the relative amounts of lysine and threonine are constant in the protein content of FSFM, however, the ratio of MET and HIS increase if the protein content goes up. The ratio of the remaining essential amino acids declines when the protein content increases. It means the amino acid content of SFM cannot be predicted accurately from the crude protein. For poultry, the protein quality of SFM is higher than those of soybean meal, maize or wheat. So, could be used efficiently as a substitute for soybean meal in diet formulations.

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