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Evaluation of the Effect of Processing on Sunflower Protein Quality

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ABSTRACT

The protein quality of sunflower meal, sampled at different processing steps, was studied. The protein quality was evaluated in terms of the 'available lysine' by the modified Carpenter method, and the biological value (BV) was determined by the Tetrahymena pyriformis *test. The samples obtained from two oil expressors showed little change during processing, as assessed by two analytical methods. Sunflower meal heated at 110°C for various periods showed a decrease in available lysine from 3·4% to 0·9%.*

INTRODUCTION

Sunflower seed is by far the most abundant oil seed crop in South Africa. The annual production is about 340 000 tons (Taylor & Reinhardt, 1980) and is used mainly as an oil source. The meal, after oil extraction, has a high fibre content (16%) which limits its use as a nutritional source (J. Evrard, CETIOM, France, 1981; pers. comm.).

Sunflower meal contains no anti-nutritional components and the amino acid composition of its protein complies with the FAO pattern, with the exception of lysine (Gassman, 1983).

Lysine, apart from being the limiting amino acid in sunflower protein, also contains a free ε-amino group which may be bound during processing, making it less available nutritionally (Maillard reactions).

During processing and oil extraction, high pressures and temperatures are applied to the sunflower seeds. Many seemingly contradictory reports

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have been published on the extent of the damage done to the sunflower protein during processing.

Brad (1967) found that thermal treatment of sunflower seed at 100 °C for 30 min, and 100 °C for 15 min, improved the digestibility of the protein by pepsin and trypsin and caused a decrease in the protein solubilities.

In 1978, a research committee in South Africa (W. A. Odendaal, Animal and Dairy Sciences Research Institute, Irene, RSA, 1978; pers. comm.) found that significant damage was done to the protein in sunflower meal during processing. The most damage was done to the lysine, whereas arginine and tryptophan were affected to a lesser extent. Feeding tests on pigs showed a decrease in the biological value of the sunflower protein due to processing.

In a study of the effect of the industrial extraction process on protein quality in sunflower meal, Rossi & Germondari (1982) noticed a decrease in total lysine, while the *in vitro* digestibility of the protein was between 80% and 86%.

On the other hand, Battersham & Major (1982), in assessing the lysine availability in sunflower meal for pigs and chicks, found low lysine availability for pigs (0·54–0.66), but higher lysine availability for chicks (1·01–0.93). The above figures express the availability as a proportion of the total lysine.

Dreher *et al.* (1983) in their study on sunflower butter, noticed a decrease in total lysine during roasting, although the protein digestibilities remained unchanged.

In a study conducted at the Texas A & M University (1978), the solubilities and total lysine of prepressed cake and direct solvent-extracted flour were quite similar.

The differences between the results of the studies are apparently due to variations in experimental and processing conditions. In none of the reported studies was the effect of the different processing steps evaluated.

The purpose of this study was to investigate the effect of each individual processing step on the availability of the lysine in sunflower protein.

MATERIALS AND METHODS

Samples

Samples of sunflower cake were obtained from two commercial oil expressors, A and B. The samples were drawn during the different

processing steps: sunflower seeds, conditioned seeds, pressed cake, solvent-extracted cake and desolventized cake.

Chemical analyses

Nitrogen was determined by the Kjeldahl method. Available lysine was determined as fluoro-dinitro-benzene-reactive lysine (FDNB-lysine) according to the method of Carpenter, as modified by Booth (1971). Apart from the standard 16 h digestion in an oil bath, an alternative autoclave digestion (Kreienbring & Meier, 1978), modified to 0·5 h and 1·0 atm was tested. The results were in good agreement. Analyses were carried out on the samples as received from the expressors and on the same samples after defatting with hexane.

Sunflower meal was heated in an oven at 110 °C for different periods to assess the effect of heat on FDNB-reactive lysine.

The biological value (BV) was estimated microbiologically by the *Tetrahymena pyriformis* test (Robbins, 1974).

Instrumentation

Gilford SP 2400 S spectrophotometer.

Autoclave: Electric steroclave, Wisconsin Aluminium Founding Co. Inc.

RESULTS AND DISCUSSION

Table 1 shows the BV and FDNB-lysine of sunflower samples. The results were corrected for losses by a factor of 1·2 (Booth, 1971). It is clear that little change in the FDNB-reactive lysine of sunflower meal and cake occurred during processing. The accuracy of the method was tested by sixfold analyses of a commercial casein sample used in animal feeding experiments. An average of 8·56 g available lysine/16 gN was found, which compared well with the established value of 8·61 g/16 gN (Smith & Friedman, 1984). Six replicates of sunflower meal analyses by the Booth method, using both methods of digestion, gave a standard deviation of 5·03 %. In the case of the defatted A samples, the decrease, which was the largest observed, amounted to only three times the standard deviation. Non-defatted and defatted samples differed slightly in their lysine values.

TABLE 1
Microbiological Evaluation and FDNB-Lysine of Sunflower Samples from Two Expressors

Sample	*Available lysine*[b] *(g/16 gN)*		
	BV[a,b]	*Defatted sample*	*Commercial sample*
Expressor A			
Dehulled seed	85·7 ± 1·7	3·31 ± 0·02	3·50 ± 0·05
Conditioned seed	81·7 ± 1·0	3·14 ± 0·18	3·55 ± 0·13
Prepressed cake	79·5 ± 1·6	3·13 ± 0·05	3·10 ± 0·05
Solvent-extracted cake	78·9 ± 1·5	3·21 ± 0·11	3·14 ± 0·37
Desolventized cake	72·9 ± 1·0	2·83 ± 0·11	3·19 ± 0·07
Expressor B			
Dehulled seed	79·2 ± 1·9	3·00 ± 0·07	3·20 ± 0·28
Conditioned seed	76·1 ± 3·0	3·12 ± 0·18	3·10 ± 0·07
Prepressed cake	76·3 ± 4·5	2·87 ± 0·20	2·83 ± 0·14
Solvent-extracted cake	88·3 ± 3·9	3·11 ± 0·34	2·83 ± 0·07
Desolventized cake	75·2 ± 4·4	3·02 ± 0·19	2·90 ± 0·05

[a] Relative to defatted whole egg powder with a BV of 93·8%.
[b] Average of three determinations.

The differences were small and no clear trend could be shown. This observation is in agreement with the study conducted at the Texas A & M University (1978).

The *Tetrahymena* test showed a moderate decrease in the biologically available lysine for both sets of samples, with the decrease being more pronounced in the A samples.

In their studies on protein-enriched biscuits, Noguchi *et al.* (1982) and Björk *et al.* (1983) noticed that losses in FDNB-lysine resulting from Maillard reactions could vary from 0% to 40%, depending mainly on water content and temperature. Increases in moisture content causd decreased lysine losses, whereas the losses increased at higher temperatures. During conditioning the moisture content of the sunflower seed is increased and, consequently, the protective effect on the lysine is increased. This may explain the relative stability of the lysine during processing.

Table 2 shows that the FDNB-reactive lysine decreased with time. After 4 h the lysine decreased from 3·4% to 0·9%.

Processing conditions vary from one plant to another. During

TABLE 2
Sunflower Cake Heated at 110 °C for Various Periods
(Correction factor 1·2)

Heating time (min)	*Available lysine (g/16 gN)*
0	3·4
10	3·4
20	3·4
30	2·9
90	2·9
120	2·9
150	2·8
180	2·7
210	1·0
240	0·9

conditioning, the sunflower seeds may be exposed to steam treatment at 100 °C for 20 min. Consequently, the moisture content is reduced at up to 115 °C (Gunstone & Norris, 1983). During the pressing step, pressures ranging between 15 000 and 20 000 psi are applied, which may cause the temperature to rise to 140 °C. Oil remaining in the pressed cake is extracted with boiling hexane. Desolventizing is performed at 100 °C under reduced pressure.

The determination of FDNB-reactive lysine and other *in vitro* methods do not reflect changes in the protein digestibilities (Björk *et al.*, 1983). Lysine, with a free ε-amino group, may be unavailable if the adjacent peptide bond is not split in the digestive tract.

The value of the chemical methods is to monitor major changes during processing. These methods tend to overestimate lysine in samples with a low BV, as can be seen in Table 1.

It is therefore important to evaluate available lysine biologically in target animals jointly with chemical determinations so that the two methods can be correlated.

CONCLUSION

During our study we found little or no difference in the amount of available lysine between the starting material and the end product. It may, however, be necessary to either analyse a larger number of samples from different expressors, or to apply more sensitive analytical tests.

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