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Ballester,Digna; Rodrigo,R.; Nakouzi,J.; Chichester,C.O.; Yanez,Enrique; Monckeberg Fernando

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RAPESEED MEAL

II.*—Chemical composition and biological quality of the protein

By DIGNA BALLESTER,† R. RODRIGO,† J. NAKOUZI,† C. O. CHICHESTER, E. YÁÑEZ** and F. MÖNCKEBERG**

The chemical composition (moisture, ash, protein, amino acids, ether extract, crude fibre, Ca, P, Fe, thioglucosides, isothiocyanates and oxazolidinethiones) and biological quality (net protein utilisation, available lysine and digestibility) were investigated in 12 samples of presscake meal of rapeseed (*Brassica napus*) collected from local factories. Crude fibre and mineral contents were comparatively high. Thioglucosides and their hydrolysis products (isothiocyanates and oxazolidinethiones, which are toxic) were found in high concentrations. All samples showed a high protein content and their amino acid patterns corresponded to a good-quality protein with a score of 80, and an adequate level of available lysine. Nevertheless, the biological quality measured as net protein utilisation and digestibility gave low values, which could be explained on the basis of the presence of the toxic factors and the high level of crude fibre, respectively.

Introduction

The cultivation of rapeseed (*Brassica napus*) as a source of edible oil has spread to many areas of the world. In Chile, its cultivation has increased markedly during recent years, reaching 87,000 tons a year,[1] and has made its use the largest among oil-bearing seeds. In addition to its importance as an oil-seed it is a potential source of protein, because after oil extraction a presscake is left that contains about 35% protein. However, before this material can be used extensively it will be necessary to solve the problem posed by the presence of goitrogenic[2] and growth-inhibitory factors[3] which are thioglucosidic in nature.[4,5]

This paper deals with the chemical composition of rapeseed presscake meal, with emphasis on the concentration, of thioglucosides and the products of their hydrolysis, isothiocyanates [3-butenyl isothiocyanate] and oxazolidinethiones [L-5-vinyl-2-oxazolidinethione] (VTO), and its biological quality measured as net protein utilisation, available lysine, amino acid content and digestibility.

Experimental

Materials

12 samples of solvent-extracted rapeseed presscake meal obtained from local industries (A, B, C), and produced on different dates (1, 2, 3, 4) were used for chemical analysis.

Chemical methods

Water, total ash, calcium, phosphorus, iron, ether extract and crude fibre were determined according to A.O.A.C. methods.[6]

Nitrogen content was determined by the Kjeldahl method using a macrodigestion procedure,[5] followed by a semimicro distillation in a Markham apparatus. The ammonia produced was distilled into 2% boric acid containing a mixed indicator.[7]

Amino acid analysis was performed by microbiological methods[8] from a pooling of samples from one of the industries (B). About 0·5 g of protein was refluxed with 60 ml of 20% by vol. HCl for 8 h (2 h for cystine).

Caloric content was calculated by using the factors 4, 9, 4 of Atwater.

Available lysine was determined using the 2,4-dinitrofluorobenzene (DNFB) procedure of Carpenter.[9]

Thioglucosides were determined by the procedure of McGhee *et al.*[10]

Isothiocyanates (3-butenyl isothiocyanate) and oxazolidinethiones [L-5-vinyl-2-oxazolidinethione] (VTO) were measured by the enzymic method described by Appelqvist & Josefsson.[11]

Biological measurements

The samples of each industry were pooled in order to measure their biological quality.

Net protein utilisation (*NPU*) was determined in 31-day old rats according to the method of Miller & Bender.[12]

Nitrogen digestibility was measured in the same experiment using the formula:

$$\text{True nitrogen digestibility} = \frac{I-(F-F_k)}{I} \times 100$$

where I = dietary nitrogen intake of the animals on the experimental diet, F = faecal nitrogen on the test animals and F_k = faecal nitrogen of the animals on the protein-free diet.

Results

Chemical analysis

The results of the chemical analyses are given in Tables I and II. In general the values show only a slight variation in the chemical composition, which reveals that the processing and seed varieties used by the three industries were similar. Only minor differences in the moisture and fat content were observed in samples of industry B. The protein, crude fibre, and ash contents were comparatively high and were similar in all samples. The calorie content ranged from 305 to 317 kcal/100g.

In general, the thioglucosides varied from 2·65 to 3·30%, the lowest being those of B. The isothiocyanate content showed a mean value of 1·4 mg/g and the VTO content was 7·6 mg/g. A good stoicheiometric correlation was observed

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† Present address: School of Chemistry and Pharmacy and Biochemistry, University of Chile, Casilla 233, Santiago, Chile

** Present address: Pediatrics Research Laboratory, Hospital Arriaran, Casilla 5370, Santiago, Chile

TABLE I

Gross chemical composition and calorie content of rapeseed presscake meal obtained from three different factories and produced on different dates

Origin	Moisture, %	Ash, %	Protein (N × 6·25)	Ether extract, g/100g	Crude fibre, g/100g	Ca, mg	P, mg	Fe, mg	N-free extract*	Calorie content, kcal/100 g
Industry A:										
A-1	5·4	6·0	34·8	3·8	14·0	667	1050	15	36·0	317
A-2	5·3	6·2	34·0	2·5	14·0	658	1048	15	38·0	310
A-3	5·7	5·9	35·0	3·0	14·1	670	1042	14	36·3	312
A-4	5·3	6·3	34·4	2·5	14·7	669	1052	15	36·8	307
Mean	5·4	6·1	34·6	3·0	14·2	666	1048	15	36·7	312
Industry B:										
B-1	9·9	6·1	33·4	1·7	14·1	669	1068	14	34·8	310
B-2	9·6	6·0	31·2	1·6	13·9	672	1053	15	37·7	312
B-3	8·8	6·1	33·7	1·9	13·8	670	1071	14	35·7	313
B-4	9·2	6·3	34·1	2·0	13·9	677	1075	14	34·5	305
Mean	9·4	6·1	33·1	1·8	13·9	672	1067	14	35·7	310
Industry C:										
C-1	6·9	5·8	34·1	2·8	13·4	648	943	17	37·0	310
C-2	6·7	5·8	34·2	3·2	13·5	652	947	18	36·6	312
C-3	6·6	6·0	33·4	3·3	13·2	640	952	17	37·5	313
C-4	6·8	6·6	34·5	3·0	14·1	650	953	16	35·0	305
Mean	6·8	6·0	34·0	3·1	13·6	648	949	17	36·5	310

* Calculated by difference

TABLE II

Thioglucosides, isothiocyanates [3-butenyl isothiocyanate] and oxazolidinethiones [L-5-vinyl-2-oxazolidinethione] of different samples of meal

Origin	Thioglucosides,[a] g/100g	Isothiocyanates,[b] mg/g	Oxazolidinethiones,[c] mg/g
Industry A:			
A-1	3·12	1·51	7·93
A-2	3·09	1·52	7·82
A-3	3·05	1·48	7·79
A-4	3·10	1·49	7·86
Mean	3·09	1·50	7·88
Industry B:			
B-1	2·67	1·38	6·58
B-2	2·65	1·36	6·57
B-3	2·69	1·39	6·64
B-4	2·70	1·38	6·70
Mean	2·68	1·38	6·62
Industry C:			
C-1	3·30	1·36	8·39
C-2	3·15	1·33	8·27
C-3	3·18	1·30	8·32
C-4	3·28	1·35	8·35
Mean	3·23	1·33	8·33

[a] 2(R)-hydroxy-3-butenyl sodium glucosinolate
[b] 3-butenyl isothiocyanate
[c] L-5-vinyl-2-oxazolidinethione

between the content of thioglucosides and their hydrolysis products. The difference between isothiocyanate and VTO was due to the fact that only the former is volatile.

The values for different amino acids are presented in Table III.

Biological tests

The *NPU*, true digestibility and available lysine values are presented in Table IV. *NPU* and true digestibility results showed that the net quality of the protein was poor in spite of its apparent score as calculated on the basis of its amino acid composition. Nevertheless, all samples showed an acceptable level of available lysine. Differences in the above levels between samples were fairly small.

Discussion

The chemical composition of the rapeseed presscake meal was very similar in all the samples analysed, a predictable finding since the raw materials and the process were the same in every case.

The high protein content of this meal is in agreement with values reported by other authors,[13,14] and thus this product represents a large potential source of protein.

The high fibre content found in all samples could be an unfavourable factor in its future utilisation. On the other hand, rapeseed meal presscake is a good source of minerals such as Ca, Fe and P.

The thioglucoside content, even in small quantities, is important since it is related to the toxic effects observed in experimental animals fed this product.[4] It is known that isothiocyanate and VTO are released by enzymic hydrolysis, the latter being directly responsible for the toxicity of rapeseed presscake meal.[5] The values found for these substances agree with those reported in the literature.[15-17]

The values of the essential amino acid revealed a pattern resembling the protein quality of casein, with its limiting amino acid being methionine. This finding closely agrees with those reported by Clandinin and other workers.[5] However, this was not confirmed by the biological tests. This could be explained by a lower availablity of amino acids such as methionine and/or the presence of the above-mentioned substances.

TABLE III
Partial amino acid content of meal*

Amino acid	g/16g N	Organism
Isoleucine	3·6	*Leuconostoc mesenteroides* P60
Leucine	5·9	*Streptococcus faecalis* 9790
Lysine	4·8	*Leuconostoc mesenteroides* P60
Phenylalanine	3·3	" "
Cystine	1·6	" "
Methionine	1·8	" "
Threonine	3·7	*Streptococcus faecalis* 9790
Valine	5·9	" "
Histidine	2·1	*Leuconostoc mesenteroides* P60
Arginine	7·2	" "

* Tryptophan was not measured

TABLE IV
Available lysine, net protein utilisation (*NPU*) and true digestibility of meal

Origin	Available lysine, g/100g crude protein	*NPU*	True digestibility
Industry A:			
A–1	4·50		
A–2	4·40		
A–3	4·38		
A–4	4·41		
Mean	4·42	41	68
Industry B:			
B–1	3·90		
B–2	3·97		
B–3	4·16		
B–4	4·10		
Mean	4·03	39	66
Industry C:			
C–1	4·60		
C–2	4·58		
C–3	4·51		
C–4	4·61		
Mean	4·58	39	65

Bell and other workers[2,3] have demonstrated that isothiocyanate and VTO inhibit growth and cause a clear goitrogenic effect. In addition, Ballester *et al.*[18] found a toxic effect on the liver of rats fed a diet containing 20% protein calories from a similar meal in an experiment that lasted 2 months.

The present results seem to confirm the good quality of the protein of rapeseed presscake meal, but its utilisation by the rat is impaired by the presence of toxic substances. Further research is necessary to remove them or reduce their level before rapeseed can be used as a food.

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Department of Food Science and Technology,
University of California,
Davis,
Calif. 95616, U.S.A.

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