Food Chemistry **35** (1990) 229–235

Technical Note

Studies on Tropical Vegetables. Part 1: Seed Amino, Fatty Acid and Glucosinolate Profile of Ethiopian Mustards (*Brassica carinata* Braun)

ABSTRACT

*Amino acid analyses in seed of local Ethiopian mustard (*Brassica carinata *Braun) show high levels of (in g/100 g protein) glutamic acid (20·7), arginine (10·8) and proline (6·5), while histidine (2·9) and tyrosine (2·5) were lowest. Variation between selections existed. 'Mulio giant' has consistently high values while 'CRRS-5' and 'Figiri white' were lower. Mean amino acid contents in local Ethiopian mustard were comparable to that of rape 'Double-zero'. Crude protein in Ethiopian mustard seed (47·6%) was higher than in 'Double-zero' (38·7%). While erucic acid (40·6%) was a major fatty acid in Ethiopian mustard and to a lesser extent oleic, linoleic and linolenic acids, 'Double-zero' showed the opposite trend (despite similarities in iodine and saponification numbers). Ethiopian mustards had higher glucosinolates (79·7 μmoles/g), mainly sinigrin (77·2 μmoles/g), and lower gluconapin and progoitrin than 'Double-zero', whose glucosinolate content was 10 μmoles/g. Although 'Figiri white' had no gluconapin, it had the highest sinigrin (99 μmoles/g) compared to 58 μmoles/g in 'Mulio giant'.*

INTRODUCTION

Ethiopian mustard (*Brassica carinata* Braun) is an important green leafy vegetable in Zambia and in most parts of tropical Africa (Grubben, 1977). It is an allopolyploid of *B. nigra* and *B. oleracea* while rape (*B. napus* L.) resulted from a cross between *B. nigra* and *B. oleracea* (U, 1935). Although *B. carinata* seed is oleagenous and is in common use in its native Ethiopia (Westphal & Marquard, 1981), it has not been developed as an oil seed crop

Food Chemistry 0308-8146/90/$03·50

elsewhere despite the continued search for cheaper sources of edible or industrial oils and feed.

Numerous studies have reported fatty acid composition of rape and low glucosinolate–low erucic acid (double–low) cultivars (Morice, 1983), which are major oil seed types in the temperate zone. 'Double-zero' rape was recently introduced in Zambia where it has seed setting ability. Its seed composition with regard to amino acids, fatty acids and glucosinolates, in comparison to that of selections of *B. carinata*, is reported in this paper.

MATERIAL AND METHODS

Six indigenous Ethiopian mustard (*B. carinata* Braun) selections and a rape ('Double-zero') were field-grown during a mild winter in Mazabuka (approximately 900 m above sea level and latitude 15° S). Harvested seed was analysed by Svalof AB Laboratories in Svalöv, Sweden. Chemical analysis of the oil for iodine and saponification numbers were carried out according to the standard methods of the AOAC (1980).

The fatty acid methyl esters were extracted according to the procedures described by Uppstrom and Johansson (1978). Crude protein was analysed using the Kjeldahl method while amino acids in the defatted meal were analysed on duplicate samples by high-pressure liquid chromatography with a pre-column derivatization agent. Glucosinolates (sinigrin, progoitrin and gluconapin) were analysed according to procedures developed by Heaney and Fenwick (1980) as detailed by Uppstrom (1983).

RESULTS

Mean crude protein and lipid content in local selections of Ethiopian mustards were 47·6% and 29·3%, respectively, as opposed to 38·7% and 46·9% for 'Double-zero' in that order (Table 1). Lipid iodine and saponification numbers were similar. Fatty acids analyses (Table 2) revealed that erucic acid (40·6%) was a major component in Ethiopian mustard seed oil which had less oleic acid as compared to 'Double-zero' which had only 2·4% erucic acid and 61·4% oleic acid. The glucosinolate analyses (Table 3) indicated that sinigrin was a larger component than either gluconapin or progoitrin in Ethiopian mustards, whose mean value (72·2 μmoles/g) was higher than 'Double-zero' (1 μmole/g sinigrin). 'Figiri white' had no gluconapin while 'Double-zero' had comparatively higher gluconapin and progoitrin.

Amino acid contents showed variation between Ethiopian mustard selections (Table 4). Mean values for Ethiopian mustards were much higher

TABLE 1
Protein, Lipid Content and Characteristics of Seed Oil of Ethiopian Mustard Selections and Rape in Comparison to 'Double-zero'

Selections	*Crude protein (% dry matter)*	*Lipid content (% dry matter)*	*Iodine number*	*Saponification number*
CRRS-5	44·8	23·5	109	176
CRRS-5	52·6	30·5	112	176
Lepu	44·7	23·6	108	176
Mulio giant	40·3	28·7	111	175
Figiri purple	50·3	39·0	111	175
Figiri white	52·9	31·6	114	175
Mean	47·6	29·5	111	176
Double-zero	38·7	46·9	115	189

TABLE 2
Fatty Acid Composition in Seed of Ethiopian Mustard (*Brassica carinata* Braun) Selections in Comparison to 'Double-zero' and Swedish Oil Seed Rape

Selections	*Fatty acids (% of total fatty acids)*					
	Palmitic	*Palmitoleic*	*Stearic*	*Oleic*	*Linoleic*	*Linolenic*
	(16:0)	(16:1)	(18:0)	(18:1)	(18:2)	(18:3)
CRRS-2	3·8	0·3	1·0	15·5	23·6	8·4
CRRS-5	3·3	0·1	0·8	13·9	18·1	12·1
Lepu	3·3	0·8	0·8	14·7	20·2	9·1
Mulio giant	3·4	0·3	0·9	10·3	19·7	11·4
Figiri purple	2·7	0·2	0·9	12·1	17·8	11·7
Figiri white	2·7	0·2	0·9	12·1	17·8	11·7
Mean	3·2	0·2	0·9	13·0	19·9	10·8
Double-zero	3·1	0·3	1·1	61·4	19·4	9·8
Oil seed rape[a]	5·0	0·3	1·2	55	12	0·5
	Arachidic	*Eicosenoic*	*Eicosadienoic*	*Behenic acid*	*Erucic acid*	*Docosadienoic*
	(20:0)	(20:1)	(20:2)	(22:0)	(22:1)	(22:2)
CRRS-2	0·6	7·8	0·7	0·4	36·8	1·1
CRRS-5	0·5	8·6	0·8	0·2	40·5	1·1
Lepu	0·6	8·4	0·7	trace	40·9	1·2
Mulio giant	0·7	8·5	1·0	trace	42·2	1·6
Figiri purple	0·7	9·5	1·0	0·1	42·1	1·2
Figiri white	0·6	8·5	0·9	trace	40·9	1·3
Mean	0·6	8·55	0·8	0·2	40·6	1·3
Double-zero	0·4	2·0	0·1	trace	2·4	trace
Oil seed rape[a]	0·5	1·5	0·6	0·4	0·4	0·4

[a]Adapted from Johnsson and Uppstrom (1986).

TABLE 3
Content of some Glucosinolates in Seeds of Ethiopian Mustard Selections in Comparison to 'Double-zero' Rape grown under Similar Conditions

Selections	*Glucosinolates (μmoles/g defatted dry matter)*			
	Sinigrin	*Gluconapin*	*Progoitrin*	*Total*
CRRS-2	74	2	2	78
CRRS-5	92	1	2	95
Lepu	61	1	1	63
Mulio giant	58	1	1	60
Figiri purple	79	1	1	82
Figiri white	99	0	1	100
Mean	77·2	1·0	1·5	79·7
Double-zero	1	3	5	10

than those in 'Double-zero'. Glutamic acid, arginine, aspartic acid, leucine and proline were among the most abundant in both Ethiopian mustard and rape seed, while histidine and tyrosine were least.

DISCUSSION

Seeds of local *B. carinata* contain less oil (23·5–39%) than rape (*B. napus* L., 45%), in agreement with data of Daun (1983), selections in Ethiopia (41%) reported by Westphal and Marquard (1981) and 'Double-zero' (46·9%). The physico-chemical characteristics reflect a high degree of unsaturation comparable to other edible vegetable oils (Swern, 1979). The erucic acid content of 40% is comparable to that in unimproved rapes as reported by Amelotti and Benelli (1976) and Lizana and Valdivia (1979). However, its level in 'Double-zero' of 2·4% is high, possibly due to cultural techniques as reported by Bengtsson *et al.* (1979).

Glucosinolate levels are high in comparison to the data of Xu and Chu (1982) on *Brassica* spp. The major component in Zambian selections is sinigrin. However, gluconapins and progoitrins are present in very small quantities in *B. carinata* selections, contrary to the report of Bechyne and Downey (1982) that sinigrin is the only glucosinolate found. 'Double-zero' had relatively higher levels of gluconapin and progoitrin.

Crude protein levels are higher in *B. carinata* selections studied than those in Ethiopia (26%) (Westphal & Marquard, 1981), rape (25%) (Duan, 1983) and 'Double-zero'. This is reflected in the relatively higher amino acid levels in some. The abundance of glutamic acid, arginine and aspartic acid is

TABLE 4
Amino Acid Composition (g/100 g crude protein) in Seeds of Ethiopian Mustard Selections in Comparison to 'Double-zero' Rape and Leguminous Seeds (Soyabean and Groundnut)

Amino acid	*Selections*				
	CRRS-2	*(CRRS-5)*	*Lepu*	*Mulio giant*	*Figiri purple*
Glutamic	20·3	20·0	21·4	23·7	21·3
Arginine	8·0	8·3	9·3	10·2	8·8
Aspartic	7·0	6·2	7·2	7·9	5·8
Leucine	6·7	6·7	7·0	6·9	6·8
Proline	6·4	6·2	6·8	6·3	6·8
Valine	5·0	4·9	5·1	5·1	6·8
Glycine	4·8	4·7	5·1	5·1	4·9
Serine	4·3	4·0	4·5	4·3	4·7
Phenylalanine	4·2	3·7	3·9	3·8	4·2
Lysine	4·2	4·2	4·2	4·5	3·8
Threonine	4·1	3·7	4·1	4·2	4·4
Isoleucine	4·1	3·9	4·2	4·1	3·9
Alanine	3·8	3·7	3·9	4·1	4·0
Histidine	2·7	2·7	2·9	2·9	3·8
Tyrosine	2·7	2·5	2·6	2·7	2·4
	Figiri white	*Mean*	*Double-zero*	*Groundnut*[a]	*Soyabean*[a]
Glutamic	20·8	20·7	17·9	12·6	15·7
Arginine	8·6	10·8	7·6	7·1	5·6
Aspartic	6·33	6·6	8·1	7·2	10·4
Leucine	6·6	6·8	7·3	4·2	6·2
Proline	4·8	6·5	6·1	2·9	4·1
Valine	4·8	4·9	5·6	2·7	4·3
Glycine	4·4	4·8	5·2	3·8	3·9
Serine	3·8	2·5	4·9	3·4	3·3
Phenylalanine	3·8	3·9	4·1	3·5	3·7
Lysine	4·8	4·3	5·1	2·1	5·2
Threonine	3·8	3·9	4·6	1·7	3·8
Isoleucine	4·1	4·1	4·4	2·2	3·9
Alanine	3·6	3·8	4·3	2·5	4·1
Histidine	3·1	2·9	2·9	1·4	2·1
Tyrosine	2·5	2·5	3·0	2·5	2·0

[a]Adapted from Jansen *et al.* (1979).

consistent with amino acid profiles in seeds of many plants. On account of higher crude protein and amino acid levels compared to groundnuts and soyabean (Table 4), defatted seed meal of local *B. carinata* selections might have potential for use in feeds with the precautions elaborated by Eggum (1981). Research efforts, however, to increase seed yield above its current ceiling at 2·5 tonnes/ha in Zambia (Mnzava, 1986), and breeding for reduced glucosinolates and erucic acid, is essential.

ACKNOWLEDGEMENTS

We thank Svaloef AB Chemical Laboratories for carrying out the analyses, technical aid under the GRZ/SIDA–ASSP which made this study possible, and the Director of Agriculture, MAC, for permission to publish this paper.

REFERENCES

Amelotti, G. & Benelli, T. (1976). Fatty acid and sterol composition of rape oil. *Sementi Elette*, **21**(5/6), 21–6.

AOAC (1980). *Official Methods of Analysis* (13th edn). Association of Official Analytical Chemists, Washington, DC.

Bengtsson, A., Ohlsson, I. & Tegnell, I. (1979). Erucic acid and cultivation technique. In *Proc. 5th Int. Rapeseed Conf., Vol. 1*, Malmö, Sweden, pp. 272–5.

Bechyne, M. & Downey, R. K. (1982). The effect of photoperiod on the characteristics of oil and meal of Abyssinia mustard (*Brassica carinata* Braun). *Sbonvnik Vysoke Skoly Zemed. Praze Fac. Agron.*, **37**, 97–106.

Daun, J. K. (1983). The composition of wild mustard and some other cruciferous weed seed and the effect of admixture on the quality of rape seed. In *Proc. 6th Rapeseed Conf.*, Paris.

Eggum, B. O. (1981). Nutritional problems related to double–low rape in animal nutrition. *World Crops*, **5**, 293–310.

Grubben, G. J. H. (1977). *Tropical Vegetable and Their Genetic Resources*. FAO, Rome, 197 pp.

Heaney, R. K. & Fenwick, G. R. (1980). The analysis of glucosinolates in *Brassica* species using gas chromatography, direct determination of thiocyanate, ion precursors, glucobrassicin and neoglucobrassicin. *J. Sci. Food Agric.*, **31**, 593–9.

Jansen, W. M. M., Tarpstra, K., Beeking, F. F. E. & Bisalsky, A. J. N. (1979). *Feeding Values for Poultry* (2nd edn). Spelderholt Institute for Poultry Research, Beckbergen, The Netherlands.

Johnsson, R. & Uppstrom, B. (1986). Quality breeding in rapeseed. In *Svalöf 1886–1986—Research and Results in Plant Breeding*, ed. G. Olsson. Svalof AB, Sweden, pp. 173–83.

Lizana, N. & Valdivia, V. (1979). Rapeseed production and research in Chile. In *Proc. 5th Int. Rapeseed Conf., Vol. 1*, Malmö, Sweden, pp. 276–9.

Mnzava, N. A. (1986). Compensatory leaf and seed yield increase in vegetable mustard (*Brassica carinata* A Braun) in response to defoliation intensity. *Hort. Sci.*, **21**(3), 723.

Morice, J. (1983). A new rape ('Double-zero'). *Comptes Rendus*, **69**(17), 1493–502.

Swern, D. (1979). *Bailey's Industrial Oil and Fat Products, Vol. 1*. John Wiley and Sons, New York.

U, N. (1935). Genome analysis in brassica with special reference to the experimental formation of *B. Napus* and peculiar mode of fertilisation. *Jap. J. Bot.*, **7**, 389–452.

Uppstrom, B. & Johansson, S. A. (1978). Methods of determination of fatty acids adapted to a breeding programme. In *Proc. 5th Int. Rapeseed Conf., Vol. 1*, Malmö, Sweden, pp. 140–4.

Uppstrom, B. (1983). Glucosinolate pattern in different growth stages of high and low glucosinolate varieties of *Brassica napus*. *Sveriges Utsadesforen. Tidskrift*, **93**, 331–6.

Westphal, A. & Marquard, R. (1981). Yield and quality of *Brassica* spp. in Ethiopia. *Plant Res. and Devel.*, **13**, 114–27.

Xu, U. L. & Chu, L. (1982). The glucosinolate content of major rape cultivars in China. *Scientia Agronomica Sinica*, **3**, 323–7.

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(Received 15 April 1988; revised version received and accepted 19 April 1989)