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Assessment of oil and seed meal quality parameters of rapeseed-mustard group of crops

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ABSTRACT

Oil, protein, glucosinolates, fibre content and fatty acid profile were investigated in 43 rapeseed-mustard varieties. Oil content ranged from 36.5 % in karan rai variety 'PC 5' to 43.5 % in 'Jhumka', a yellow sarson variety. The maximum (20.7%) and minimum (17.6%) protein content was recorded for a variety of 'GSL 1' *gobhi sarson* ('GSL 1') and 'Jhumka' yellow sarson, respectively. A wide variation was observed for different fatty acids. Gobhi sarson varieties ('Neelam' and 'Sheetal') and of brown sarson ('KBS 3') had oleic acid in the range of 22.5–32.2 %. The oleic to linoleic and ω-6 to ω-3 fatty acid ratio were very low, the highest was 1.7 and 2.4, respectively. 'GSL 1' and 'Sheetal' of *gobhi sarson*; 'Pusa Gold' and 'Jhumka' of yellow sarson showed low level of linolenic acid (< 10%). Glucosinolates content in all the varieties was much higher than the desired level of < 30 µ moles / g defatted seed meal. Two varieties 'RCC 4' of Indian mustard and 'Sheetal' of *gobhi sarson* had glucosinolates < 50 µ moles / g defatted seed meal. Fibre content varied substantially ranging from 6.3–18.9 %. Contrary to the belief that yellow-seeded varieties had low fibre content, two yellow *sarson* varieties had the highest fibre content. Correlation studies revealed significant and negative association of oil with protein content (r = –0.566**), saturated fatty acid (r = –0.392*) and glucosinolates (r = –0.451**). Protein content and saturated fatty acid were positively and significantly correlated with each other (r = 0.335*). Oleic acid had positive and highly significant relationship with linoleic, eicosenoic, oleic to linoleic and ω-6 to ω-3 fatty acid ratio. Glucosinolates and fibre content did not show any relationship with any of the quality parameters investigated.

Key words: Fatty acid profile, Fibres, Glucosionlates, Oil, Protein, Rapeseed-Mustard

Rapeseed-mustard (*Brassica* spp) is an important group of oilseed crops occupying second position in acreage and production after soybean [*Glycine max* (L) Merr.] in India. Rapeseed-mustard oil is an essential dietary component, especially in eastern and north-western parts of the country. Information on the nutritional and anti-nutritional make-up of rapeseed-mustard oil and seed meal would be quite useful for the breeders in the quality improvement programme. The nutritional quality and shelf-life of oil is determined by its fatty acid composition. Fatemi and Hammond (1980) reported that the rate of oxidation of oleic, linoleic and linolenic acid was in the ratio of 1:10.3:21.6, suggesting the linolenic acid to be highly prone to oxidation and oleic acid the least. The oil with high oleic acid imparting longer shelf-life and low linolenic acid is widely considered as good quality oil. Further oil should have high ratio of oleic to linoleic and linoleic (ω-6) to lionolenic (ω-3) fatty acid. Adverse effects of high erucic acid in oil (Ackman *et al.* 1977), glucosinolate content in seed-meal (Bille *et al.* 1983) and fibres (Niewiadomski 1990) are considered as anti-nutritional factors. High fibre and glucosinolates content reduce the feed value of the seed-meal. High fibre content in seed meal reflects lower value of the metabolizable energy. Indian rapeseed-mustard varieties have been reported to possess, in general, high erucic, low oleic acid and high glucosinolates (Chauhan *et al.* 2007) but information available for fibre content is scanty. Ahuja *et al.* (2002) and Chauhan *et al.* (2002a) have discussed the variability for quality characters in rapeseed-mustard germplasm including a few varieties. The detailed information on fatty acid profile and other quality characters of the rapeseed-mustard varieties is lacking; the present paper discusses the oil, protein, glucosinolates, fibre content and fatty acid profile of 43 rapeseed-mustard varieties. With the exception of toria *[Brassica rapa* var. *dichotoma* (Roxb. ex Fleming) Kitam] and brown sarson [*B. rapa* ssp *sarson* (Prain) Denford], the other selected crops-*gobhi sarson* (*B. napus* L. ssp *oleifera* DC var. *annua* L.), Indian mustard (*B. juncea* (L) Czernj & Cosson), karan rai (*B. carinata* A Braun) and yellow sarson

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[*B. rapa* var. *trilocularis* (Roxb.) Kitam] are largely self-pollinated thoughout crossing to the extent of 10–15 % in *gobhi sarson*, Indian mustard and karan rai has been reported, therefore, quality characters of breeder seed samples were analyzed to obviate the effect of outcrossing.

MATERIALS AND METHODS

The experimental materials for the present investigation consisted of breeder seed of 43 predominantly grown varieties of rapeseed-mustard:Indian mustard 27; karan rai 2; *gobhi sarson* 4; toria 6; brown sarson 2 and yellow sarson 2) received from the concerned breeder / institute during 2002–03. The analysis for oil, protein, glucosinolate, fibre content and fatty acid profile was conducted during 2004–05. Two independent samples each in duplicate were analyzed. The oil and protein content were estimated using a pre-calibrated NIR Analyser (Dicky John Instalab 600) as described by Kumar *et al*. (2003). Fatty acid profile of oil was analyzed by gas liquid chromatograph (Nucon Model 5765) using SP 2300+2310 SS column. Hyola 401, a double low hybrid of *gobhi sarson* and Varuna, non-canola variety of Indian mustard were used as checks. The detailed method for fatty acid analysis has been described elsewhere (Chauhan *et al*. 2002b). Individual fatty acid was identified on the basis of comparison of retention times with the standard samples and expressed as the percentage of total fatty acids present in the oil. Total glucosinolates content in the seed meal was estimated by complex formation between glucosinolates and sodium tetrachloropalladate solution. The intensity of the color produced was measured using ELISA reader at 405 nm (Kumar *et al*. 2004). Crude fibre content in seed meal was estimated using modified AOAC method (Ahuja and Bajaj 1999).

The range, mean, standard error of mean, coefficient of variability for different characters and simple correlation coefficients among quality characters were worked out following standard statistical methods.

RESULTS AND DISCUSSION

Rapeseed-mustard seed is mainly used for extraction of oil. Oil content determines market price and utility of the crop since purchase price of the seed is based on oil content. Thus high oil content in seed enhances the economic returns to the farmers. In the present set of varieties, oil content exhibited low variability and ranged from 36.5 % in ‘PC 5’ karan rai variety to 43.5 % in ‘Jhumka’, a yellow sarson variety (Table 1). The varieties having > 40 % oil content were ‘Pusa Bahar’, ‘Pusa Bold’, ‘Rohini’ (Indian mustard), ‘Kiran’ (karan rai), ‘Sheetal’ (*gobhi sarson*), ‘Bhawani’, ‘PT 303’, ‘PT 507’, ‘JT 1’ and ‘TH 68’ (toria), ‘Pusa Gold’ and ‘Jhumka‘ of yellow sarson (Table 2).

Seed meal obtained after oil extraction from the seed is used as an animal feed. It is a rich source of good quality proteins and can be utilized for production of value-added products like protein concentrate, baby food and biscuits after some processing. Presently, it is largely been consumed as animal feed and also being exported to some extent. Protein content of the varieties investigated showed low coefficient of variation (Table 1). The maximum (20.7%) and minimum (17.6%) protein content were recorded for a variety of *gobhi sarson* (‘GSL 1’) and yellow sarson (‘Jhumka’), respectively (Table 2).

Table 1 Range, mean and coefficients of variation (CV) for different quality parameters in rapeseed-mustard

Quality characters	Range	Mean ± SEm	CV (%)
Oil content (%)	36.5 – 43.5	39.2±0.22	3.7
Protein content (%)	17.6 – 20.7	19.5±0.10	3.5
Palmitic + stearic acid (%)	2.5 – 7.4	4.4±0.20	29.4
Oleic acid (%)	3.6 – 32.2	13.3±0.89	44.1
Linoleic acid (%)	13.0 – 27.6	18.4±0.51	18.2
Linolenic acid (%)	8.1 – 26.6	15.7±0.56	23.3
Eicosenoic acid (%)	3.4 – 14.2	7.2±0.47	42.8
Erucic acid	12.0 – 57.3	41.4±1.38	21.8
Oleic to linoleic acid ratio	0.3 – 1.7	0.7±0.04	39.9
ω-6 to ω-3 fatty acid ratio	0.6 – 1.3	0.4±0.06	33.7
Glucosinolate content*	45.5 – 107.0	74.8±2.15	18.9
Crude fibre content (%)	6.3 – 18.9	10.6±0.56	34.3

*µ moles /g defatted seed meal

Fatty acid composition of oil determines its quality. With increasing health awareness among the consumers, edible oil having higher proportion of unsaturated fatty acids are more in demand as saturated fatty acids are hypercholesteremic in nature (Mathur and Sharma 1993). The major fatty acids present in rapeseed-mustard varieties are oleic, linoleic, linolenic, eicosenoic and erucic acid. Palmitic and stearic acid were pooled together as saturated fatty acids (SFA). SFA content below 6% is desirable (Chauhan and Singh 2004). All the rapeseed-mustard varieties studied had SFA content less than 6% with the exception of ‘CS 52’, ‘RN 393’ and ‘PCR 7’ varieties of Indian mustard and ‘GSL 1’ of *gobhi sarson*. The ratio of oleic to linoleic acid (Carpenter *et al.* 1976) determines the shelf-life of the oil and the nutritional quality of the oil is determined in terms of ω-6 to ω-3 fatty acid ratio. These two fatty acids are essential fatty acids and also precursor of very long chain fatty acids (VLCFA), like arachidonic (20:4), eicosapentaenoic (20:5) and docosahexaeoic acid (22:6). VLCFA have been reported to have health beneficial effects and involved in many important metabolic functions of human body like synthesis of prostaglandinds. Fish and marine foods are the only source of VLCFA. Linoleic and linolenic acid compete for the same enzyme needed for their conversion to VLCFA but as linolenic acid has higher conversion rate, their ratio in edible oil is of quite significance (Borneo *et al.* 2007). A wide variation was observed for different fatty acids. However, mean oleic acid content was low except for *gobhi sarson* varieties, ‘Neelam’

Table 2 Oil, protein, glucosinolates (GSL), crude fibre content, fatty acid profile and related parameters in rapeseed-mustard

Variety	Oil (%)	Protein (%)	Fatty acid (%)								GSL*	Crude fibres (%)
			Saturated	Oleic	Linoleic	Linolenic	Eicosenoic	Erucic	Stability index (oleic tolinoleic ratio)	Nutritional quality index (ω-6 to ω-3 ratio)		
Indian mustard (Braasica juncea)												
'Basanti'	39.0	19.5	3.0	18.7	25.8	11.4	7.6	33.5	0.72	2.26	100.0	8.5
'CS 52'	37.4	19.0	7.2	3.6	17.8	15.4	4.4	51.2	0.42	1.16	81.2	15.0
'CS 54'	39.3	20.2	3.8	13.2	18.7	17.2	5.8	42.4	0.71	1.09	77.4	15.0
'GM 1'	39.8	20.3	5.1	6.9	13.0	21.5	6.6	46.5	0.53	0.60	59.0	11.6
'GM 2'	37.1	19.8	3.7	9.8	21.6	16.9	9.4	38.8	0.45	1.28	76.1	10.9
'Jagannath'	39.6	18.1	2.9	12.5	18.3	14.8	3.5	48.0	0.68	1.24	96.5	7.5
'JD 6'	39.4	19.7	5.4	6.5	17.1	20.0	3.4	47.6	0.38	0.86	81.5	8.9
'JM 1'	39.9	19.0	2.7	10.5	20.3	18.7	3.8	44.2	0.52	1.09	61.8	8.9
'Kranti'	39.1	19.7	3.7	12.1	15.7	19.2	6.9	42.4	0.77	0.82	74.2	9.2
'Krishna'	38.8	20.3	4.3	6.2	18.0	16.6	3.5	51.4	0.34	1.08	106.3	10.5
'Laxmi'	37.8	19.4	3.8	9.6	15.3	14.8	6.2	50.6	0.52	1.63	75.8	12.0
'PBR 91'	37.7	19.7	3.6	13.4	26.7	11.1	6.2	41.1	0.50	2.40	75.5	8.6
'PBR 97'	37.6	19.3	5.1	13.3	17.9	13.5	10.1	40.0	0.74	1.33	84.5	9.3
'PCR 7'	36.7	20.4	7.4	13.0	18.6	13.8	7.4	40.0	0.70	1.35	79.6	9.1
'Pusa bahar'	41.2	18.3	3.0	12.2	15.4	15.1	5.8	48.6	0.79	1.02	91.6	7.5
'Pusa bold'	40.6	18.3	3.6	14.0	15.0	16.4	6.2	44.9	0.93	0.91	76.0	8.4
'RCC 4'	39.1	19.5	3.7	14.1	20.7	15.4	8.3	37.9	0.68	1.34	48.7	8.3
'RH 30'	37.8	18.9	3.9	11.2	22.2	21.4	5.6	35.6	0.50	1.04	74.9	9.3
'RH 781'	39.2	19.6	4.7	14.8	14.9	18.2	7.4	40.0	0.99	0.82	76.5	14.1
'RH 819'	37.0	19.8	4.0	11.4	17.4	15.7	4.7	46.9	0.66	1.11	84.0	10.0
'RL 1359'	38.1	20.2	5.0	7.3	16.9	17.0	7.9	45.9	0.43	0.99	75.2	18.9
'RN 393'	38.0	19.8	6.4	11.4	17.8	17.0	3.8	43.6	0.64	1.05	84.1	11.6
'Rohini'	40.2	18.9	2.8	9.7	17.5	16.8	4.2	49.1	0.55	1.04	61.1	9.9
'Sanjucta Asech'	39.7	20.3	3.0	11.1	20.3	16.1	4.2	45.3	0.55	1.26	76.5	9.4
'Sej 2'	39.7	18.6	4.2	4.1	15.7	26.6	8.3	41.2	0.26	0.59	86.7	8.8
'Vardan'	39.3	19.4	3.1	9.9	16.4	20.1	5.6	44.9	0.60	0.82	64.4	7.0
'Varuna'	38.3	19.6	4.1	8.8	17.9	16.5	4.0	48.7	0.49	1.08	84.2	12.0
Karan rai (*Brassica carinata*)												
'Kiran'	40.7	19.1	4.9	12.7	15.6	17.3	12.7	38.8	0.81	0.90	67.8	11.1
'PC 5'	36.5	20.6	5.1	17.0	15.7	19.2	11.0	32.2	1.08	0.82	107.0	10.2
Gobhi sarson (*Brassica napus*)												
'GSL 1'	37.9	20.7	7.4	21.6	19.0	9.0	13.5	33.4	1.14	2.11	82.2	10.3
'GSL 2'	38.7	20.5	5.8	24.4	17.4	13.5	10.0	30.9	1.40	1.29	81.2	6.3
'Neelam'	39.3	19.9	4.0	28.7	26.2	15.8	13.2	12.0	1.10	1.66	56.9	8.3
'Sheetal'	40.9	18.8	6.0	32.2	18.8	9.8	14.2	19.0	1.71	1.92	45.5	9.7
Toria (Brassica rapa var. *toria)*												
'Bhawani'	41.0	18.9	4.4	15.7	15.1	14.5	10.5	40.1	1.04	1.04	64.0	10.4
'JT 1'	41.3	19.0	2.9	13.0	17.4	12.2	4.8	49.7	0.75	1.43	62.8	6.3
'PT 303'	40.2	20.0	4.4	13.1	27.6	19.7	4.8	30.6	0.47	1.40	59.4	11.4
'PT 507'	40.7	19.6	4.2	15.3	18.4	13.9	7.2	41.0	0.83	1.32	74.8	11.4
'TH 68'	40.6	19.1	5.1	14.7	16.4	13.5	9.5	40.7	0.90	1.22	55.4	9.3
'TL 15'	39.8	19.7	3.1	7.6	16.1	14.3	6.8	52.0	0.47	1.13	60.6	6.3
Brown sarson (Brassica rapa var. *brown sarson)*												
'KBS 3'	38.6	19.6	5.7	22.5	23.1	12.8	9.7	26.3	0.97	1.80	58.5	9.8
'KS 101'	39.6	19.3	5.9	17.5	17.6	14.7	12.5	31.7	1.00	1.20	86.3	12.8
Yellow sarson (Brassica rapa var. *yellow sarson)*												
'Jhumka'	43.5	17.6	3.7	10.9	16.3	8.1	3.9	57.3	0.67	2.01	63.2	16.7
'Pusa Gold'	40.6	19.7	2.5	14.2	17.1	9.2	4.0	53.0	0.83	1.86	76.9	16.4

* μ moles / g defatted seed meal

and 'Sheetal' and 'KBS 3' of brown sarson, which had oleic acid < 30 % (Table 2). But all the varieties had very low ratio of oleic to linoleic acid varying from 0.3-1.7 with an overall mean of 0.7 ± 0.04 (Table 1). The w-6 to w-3 ratio in all the varieties was much below than the FAO recommendation of 5-10, the highest being (2.4) for an 'PBR 91' of Indian mustard variety. The other varieties having a ratio of > 2.0 were 'Basanti' (Indian mustard), 'GSL 1' (*gobhi sarson*) and 'Jhumka' (yellow sarson) (Table 2). Variety 'PBR 91' (Indian mustard) had the highest (26.7%) while 'GM 1' the lowest (13.0%) linoleic acid. 'GSL 1' and 'Sheetal' of *gobhi sarson* and 'Pusa Gold' and 'Jhumka' of yellow sarson showed relatively low level of linolenic acid (< 10%) but still much higher than the internationally accepted norm (< 3%). Erucic acid was very high in all the varieties.

Glucosinolates are amino acid derived secondary metabolites. They are considered as the limiting factor for utilization of rapeseed-mustard seed meal. Their hydrolytic products were considered responsible for the enlargement of thyroid glands and haemorrhagic liver syndrome in animals. However, the anti-cancerous properties of some of the glucosinolates have led to interest in search of genotypes having glucosinolate content (Shapiro *et al*. 2001). Glucosinolate content in all the 43 varieties was much higher than the desired level of < 30 μ moles / g defatted seed meal. Only 2 varieties, 'RCC 4' of Indian mustard and 'Sheetal' of *gobhi sarson* had glucosinolate <50 μ moles / g defatted seed meal (Table 2).

Crude fibres, broadly considered as the sum of cellulose, hemi-cellulose, lignin and similar substances reduce the metabolizable energy of the rapeseed-mustard seed meal. Fibre content varied substantially ranging from 6.3 to 18.9% with an overall mean of 10.6 ± 0.56%. Contrary to the belief that yellow-seeded varieties had low fibre content because of thin seed coat and thereby high oil content, in the present study, two yellow sarson varieties studied had the highest fibre as well as oil content. Nevertheless, the findings need to be confirmed after evaluating large number of yellow-seeded lines / varieties. Further, dehulling of the seed reduced the crude fibre content in the seed meal (Mohapatra *et al.* 2004).

Correlation studies revealed significant and negative association of oil with protein content (r = –0.566**), SFA (r = –0.392*) and glucosinolate content (r = –0.451**). Protein and saturated fatty acids were positively and significantly correlated with each other (r = 0.335*). The relationship of saturated fatty acids was positive and significant with eicosenoic acid (r = 0.442**) and oleic to linoleic acid ratio (r = 0.313*) while negative and significant with erucic acid (r = –0.347*). Oleic acid had positive and highly significant relationship with linoleic, eicosenoic acid, oleic to linoleic and ω-6 to ω-3 fatty acid ratio. But its correlations with linolenic and erucic acid were negative and highly significant. Linoleic and erucic acid were negatively correlated (r = –0.521**). The ω-6 to ω-3 ratio had negative and significant association with linolenic acid (r = –0.817**) but positive and significant with linoleic acid (r = 0.597**) as expected. Linolenic acid also showed negative and significant association with oleic to linoleic acid ratio (r = –0.474**). The correlation of eicosenoic acid was negative and highly significant with erucic acid (r = –0.759**). However, its relationship with oleic to linoleic acid ratio was positive and highly significant (r = 0.688**). The association between erucic and oleic to linoleic acid ratio was negative and highly significant (r = –0.627**). The findings of the present investigation, in general, were in agreement to the earlier reports (Meena 2006 and Chauhan *et al.* 2007). Glucosinolates and fibre content did not show any relationship with any of the quality characters investigated.

The present investigation confirmed that none of the Indian rapeseed-mustard varieties investigated had the internationally accepted quality norms of low erucic acid (< 2%), high oleic acid (around 60 %), low linolenic acid (< 3%), high ω-6 to ω-3 fatty acid ratio (5-10) and low glucosinolates (< 30 μ moles / g defatted seed meal). But they exhibited very low SFA. Since fibre content has been considered anti-nutritional factor which lower the feed value of the seed meal, varieties like 'Vardan', 'Jagannath', 'Pusa Bahar' (Indian mustard), 'GSL 2' (*gobhi sarson*), 'JT 1' and 'TL 15' (toria) having the lower fibre content among the varieties investigated (6.3-7.5%) and 'Pusa Gold', 'Jhumka' (yellow sarson), 'GSL 1' and 'Sheetal' (*gobhi sarson*) having <10% linolenic acid should be utilized in the breeding programme to improve feed value of the seed meal and ω-6 to ω-3 fatty acid ratio in the oil.

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