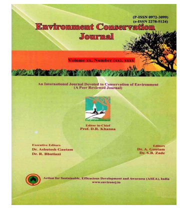
Environment Conservation Journal 23 (3):240-246, 2022

Journal homepage: https://www.environcj.in/

Environment Conservation Journal

ISSN 0972-3099 (Print) 2278-5124 (Online)



Nutritional quality evaluation of oil and fatty acid profile in various genotypes/varieties of Indian mustard [*Brassica juncea* Czern & Coss (L.)]

Durgeshwari P. Gadpayale ✉

Department of Agricultural Biochemistry, C. S. Azad University of Agriculture and Technology, Kanpur, UP. India

Alka Katiyar

Department of Agricultural Biochemistry, C. S. Azad University of Agriculture and Technology, Kanpur, UP. India

Mahak Singh

Department of Genetics and Plant Breeding, C. S. Azad University of Agriculture and Technology, Kanpur, UP. India

Lallu Singh

Department of Agricultural Biochemistry, C. S. Azad University of Agriculture and Technology, Kanpur, UP. India

ARTICLE INFO

Received : 09 December 2021
Revised : 12 March 2022
Accepted : 04 April 2022

Available online: 26 July 2022

Key Words:
Iodine value
Oil stability index
Oil content
Linoleate
Palmitate

ABSTRACT

Brassicas are one of the most agronomically eminent oilseeds that are employed as a variety of oilseed, vegetable, and fodder crops. The experiment was conducted with thirty-four genotypes/varieties seeds of Indian mustard [*Brassica juncea* Czern & Coss (L.)] for oil content, Iodine value, oil stability index and fatty acid composition during 2018-2019. The experiment was laid out in completely randomized design with three replications. The range of variability of contents of oil, palmitate, stearate, oleate, linoleate, linolenate, ecosenate, doecosenate, iodine value and oil stability index varied from 33.52 to 42.15%, 1.53 to 4.98%, 0.16 to 2.71%, 5.06 to 17.78%, 17.88 to 32.15%, 11.82 to 19.85%, 5.44 to 11.89%, 28.82 to 47.66%, 114.43 to 131.71 and 1.08 to 1.99, respectively. The *Brassica juncea* genotype-KMR-15-6 followed by genotype-KMR-17-6 had the higher oil content, oleic acid content and low value of erucic acid which indicates that seed oil this *B. juncea* species genotype is possibly suitable for both human consumption and industrial purposes.

Introduction

Oilseed crops have long held a prominent position in human nutrition, as they continue to be the major source of calories and proteins for a substantial section of the world's population. Groundnut, soybean, palm kernel, cotton seed, olive seed, sunflower seed, rapeseed mustard, sesame seed, linseed, and safflower seed are some of the most well-known oilseeds or conventional oilseeds. (Ajala *et al.,* 2014; Aremu *et al.,* 2006). *Brassica juncea*, a member of the crucifereae family of oilseeds, is the world's third largest source of edible vegetable oils, after soyabean and palm oils. Its seeds have a high energy level, with oil content ranging from 28 to 32 percent and protein content ranging from 28 to 36 percent. It contributes over 27 percent of the country's edible oil and accounts for over 30 percent of total production (Sutariya *et al.,* 2011). The fatty acid profile of mustard oil, which includes palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, ecosenoic acid, and erucic acid, determines its nutritional properties. Essential fatty acids with a content of less than 3 percent linolenic acid generally preferred for oil stability. Linolenic acid is necessary for growth and development, but it also shortens the shelf life of oil due to auto-oxidation, which causes an off flavour (Priyamedha *et al.,* 2014). Edible oil containing more than 2% erucic acid is not recommended for human consumption since it causes myocardial infarction and high blood cholesterol, although mustard oil contains a larger percentage of erucic acid, making it industrially

Corresponding author E-mail: *durgeshwarig@gmail.com*
Doi: https://doi.org/10.36953/ECJ.10132226
This work is licensed under Attribution-Non Commercial 4.0 International (CC BY-NC 4.0)
© ASEA

essential.Saturated fatty acids (SFAs) include palmitic acid and stearic acid, unsaturated fatty acids (MUFAs) include erucic acid, eicosenoic acid, and oleic acid, as well as polyunsaturated fatty acids (PUFAs) like omega-3 alpha-linolenic acid and omega-6 linoleic acid, that are nutritionally important. Conversion interfering factors for Alpha linolenic Acid (ALA) to Eicosapentaenoic Acid (EPA) and Docasahexaenoic Acid (DHA) provide a therapeutic approach in major depressive disorder. Omega-3 fatty acids play a key role in the development and function of the central nervous system. Cardioprotective properties, regulation of the inflammatory response, and a favourable impact on both central nervous system function and behaviour are among potential benefits of ALA (Reifen *et al.,* 2008). Linoleic acid is the most commonly ingested PUFA in the human diet, and while it is required for normal metabolic activities, it has been linked to inflammation and cancer when produced in excess (Fritsche *et al.,* 2013). Erucic acid in high concentrations is not recommended for human ingestion because it has been associated to cardiac lipidosis (Wendlinger*et al.,* 2014).

Material and Methods

The experiment consisting of thirty-four genotypes/varieties was carried out in Completely Randomized Design (CRD) with three replications of mustard at Oilseed Research Farm, Kalyanpur from C.S. Azad University and Technology, Kanpur under uniform agronomic conditions (80 kg N+60 kg P_2O_5+60 kg K_2O/ha) during Rabi season. The crop was irrigated two times. After harvesting seeds were sun-dried followed by oven dried before chemical analysis. The Oil content in seed was determined by soxhlet extraction apparatus by using petroleum ether of boiling point ranged between 40-60°C as described by Anonymous (2020).The oil was cooled and weighed and oil percentage was then calculated. The methyl esters of their fatty acids were prepared by the procedure of Luddy *et al.* (1968). The methyl ester was analyzed on CIC-Model Gas chromatograph using FID. The column used for fatty acid analysis was 2m x 2mm stainless steel packed with 15% DEGS on chromosorb-W (80-100 Mesh). The injector and oven temperature were maintained at 248°C and 190°C, respectively. The fatty acid composition was calculated by measuring the area under each peak by triangulation method. The iodine value was determined by method described by Jamieson (1943). Oil Stability Value was measured by procedure given by Carpenter *et al*. (1976). The statistical analysis was done by method suggested by Rangaswamy (2016).

Results and Discussion

Triglycerides content -Significant variation in oil content was noted among genotypes/varieties of Indian mustard (Table 1) that the range of variation of oil content recorded from 33.52-42.15%. The lowest and highest values of oil content were observed in genotype-KMR-17-5 and variety-Varuna, respectively. The genotypes-TM-108, TM-179 and varieties-Rohini, Urvashi exhibited 40.06%, 40.16%, 40.18% and 40.39% of oil content which was statistically at par result with Varuna. The mean oil content was recorded as 37.765% which was similar in the result of Dar *et al*. (2011), Abul-Fadl *et al*. (2011), Gupta *et al*. (2011), Singh *et al*. (2011), and Ahmad *et al*. (2012), who revealed a significant difference in oil quality traits of Indian mustard, including oil content.

Saturated fatty acid content- It is obvious from the data as shown (Table 1) that there was a significant variation in stearic acid in the Indian mustard. The highest stearic acid was statistically observed in genotype- KMR-16-6 (2.71%) and lowest was recorded in genotype-KMR-16-302 (0.16%). The similar finding exhibited closed conformity with the results of Singh *et al*., 2007 reported the range of variation of stearic acid content in Indian mustard was found to be 0.22-2.40%. Dietary stearic acid is critical for regulating mitochondrial shape and function in humans *In vivo* via a specialized signaling pathway (Senyilmaz *et al.,* 2015). In healthy guys, it aids in the improvement of thrombogenic and atherogenic risk factor profiles (Kelly *et al.,* 2001).

The data shown on palmitic acid (Table 1) of Indian mustard indicated that the variability of palmitic acid content ranged from 1.53-4.98%. The maximum and minimum values of palmitic acid were shown by genotype-KMR-16-304 and genotype-KMR-18-402, respectively. Statistically, almost similar values of palmitic acid was noted in genotypes-KMR-18-403 and TM-179.The similar

Table 1: Oil content and fatty acid profile in Indian mustard (*B. juncea*) of certain promising genotypes/varieties.

SN	Genotypes/ Varieties	Oil (%)	Fatty acid profile (%)							I.V.	O.S.I.
			16:0	18:0	18:1	18:2	18:3	20:1	22:1		
1.	TM-117	39.22	3.79	0.59	11.13	31.37	14.43	5.91	32.60	129.35	1.08
2.	TM-108	40.06	3.23	0.33	9.84	19.0	13.78	5.89	47.66	115.77	1.93
3.	TM-106	39.85	2.95	0.49	10.10	32.15	14.62	5.66	33.93	131.71	1.06
4.	TM-108-1	38.98	2.32	0.55	9.74	26.73	14.94	5.44	40.13	126.38	1.32
5.	TM-179	40.16	4.20	0.21	11.51	22.89	15.69	10.43	34.77	122.91	1.46
6.	Varuna	42.15	2.79	0.61	10.80	20.87	13.95	7.21	43.73	118.40	1.77
7.	Rohini	40.18	1.92	0.36	10.51	21.32	19.64	5.90	40.15	130.30	1.46
8.	Urvashi	40.39	3.69	0.29	8.84	18.43	17.31	7.80	43.52	121.56	1.68
9.	KMR-17-5	33.52	2.40	0.69	14.05	26.02	13.83	6.97	33.94	122.60	1.37
10.	KMR-17-6	35.11	3.23	0.38	17.78	23.99	15.92	9.83	28.82	126.12	1.41
11.	KMR-16-5	36.19	2.42	0.59	15.05	23.80	16.82	6.96	34.20	127.3	1.38
12.	KMR-16-6	35.12	1.66	2.71	11.32	20.18	13.62	9.90	40.49	121.56	1.82
13.	KMR-15-5	33.78	2.61	0.64	14.05	26.02	15.83	6.97	33.74	127.70	1.30
14.	KMR-15-6	35.79	3.23	0.38	17.78	23.99	15.92	9.83	28.82	126.12	1.41
15.	KMR-18-401	38.88	2.00	0.64	10.59	18.65	15.90	9.96	42.96	118.75	1.88
16.	KMR-18-402	36.51	4.98	0.59	5.06	26.46	16.71	7.68	38.51	126.95	1.17
17.	KMR-18-403	38.12	4.45	0.48	14.04	25.04	14.57	6.75	34.53	123.10	1.39
18.	KMR-18-404	38.25	2.75	0.43	12.34	20.60	11.82	10.54	41.50	114.43	1.98
19.	KMR-18-405	39.13	3.00	0.82	12.64	20.28	15.55	11.64	35.95	131.37	1.68
20.	KMR-18-406	36.56	3.87	0.40	9.02	17.88	14.42	8.48	45.82	115.06	1.96
21.	KMR-18-407	37.15	3.09	0.27	10.86	21.04	16.50	11.89	36.31	123.41	1.57
22.	KMR-18-408	39.69	4.01	0.46	13.08	25.36	14.64	5.30	37.11	123.84	1.38
23.	KMR-18-409	38.11	2.84	0.68	13.49	22.03	13.61	11.15	36.13	119.17	1.70
24.	KMR-18-410	36.12	2.94	0.38	9.11	19.65	14.23	8.70	44.98	117.51	1.83
25.	KMR-16-301	38.16	2.97	0.68	12.23	20.02	13.77	9.41	40.85	117.18	1.84
26.	KMR-16-302	38.16	3.97	0.16	12.97	19.38	13.89	10.94	38.41	116.35	1.87
27.	KMR-16-303	35.23	3.60	0.49	12.20	22.43	15.04	5.77	40.16	121.58	1.55
28.	KMR-16-304	33.72	1.53	0.31	5.24	18.55	19.85	9.64	44.34	127.21	1.54
29.	KMR-16-305	35.23	2.27	0.51	12.68	20.55	13.80	10.71	39.31	118.37	1.82
30.	KMR-16-306	38.11	2.37	0.75	11.91	25.39	15.21	8.96	35.71	125.96	1.39
31.	KMR-16-307	36.25	3.34	0.56	15.81	26.27	17.29	5.70	30.47	130.22	1.19
32.	KMR-16-308	39.10	3.70	0.33	13.28	18.84	13.18	9.90	40.69	114.72	1.99
33.	Ashirwad	39.68	3.30	0.87	13.98	24.57	15.20	8.00	34.30	124.69	1.42
34.	Vardan	38.19	2.85	0.30	10.28	22.08	15.83	9.23	35.89	120.80	1.47
	Mean	37.76	3.06	0.55	11.86	22.70	15.21	8.38	37.95	122.89	1.56
	C.D. at 5%	2.22	0.18	0.04	0.71	1.35	0.90	0.50	2.25	7.24	0.09
	S.E.(±)	0.78	0.06	0.01	0.25	0.47	0.31	0.17	0.79	2.56	0.03

Note: 16:0 = Palmitic acid, 18:0 = Stearic acid, 18:1 = Oleic acid, 18:2 = Linoleic acid, 18:3 = Linolenic acid, 20:1 = Eicosenoic acid, 22:1 = Erucic acid, I.V. = Iodine value, O.S.I. = Oil stability index

findings were also reported by some scientists such as Singh *et al*., 2007 and Rai *et al*., 2018 reported the variability of palmitic acid was found between range of 1.5-7.35 % and 3.08-3.85%, respectively. Palmitate has a broad range of biological activities at the cellular and tissue levels, and its steady content is ensured by its endogenous manufacture via de novo lipogenesis (Crta *et al.,* 2017). Monounsaturated fatty acid content-The result obtained on oleic acid content in genotypes/varieties of Indian mustard (Table 1) expressed that the oleic acid varied 5.06-17.78%. Genotypes-KMR-18-402 showed lowest content of oleic acid while genotypes-KMR-15-6 and KMR-

17-6 gave highest oleic acid content. Oleic acid content exhibited significant variability, the similar findings was also reported Chauhan And Kumar (2011) and Singh *et al*. (2007) who were reported the concentration of oleic acid in Indian mustard oil, a beneficial fatty acid ranged from 3.6-32.02% and 12.88-19.04%, respectively. Oleic acid, a major component of the Mediterranean diet, is thought to have a wide range of physiological effects, including a protective effect against cancer, autoimmune and inflammatory disease, and the ability to aid wound healing, metabolic disturbances, and skin injury and prominent role in drug absorption (Sales-Campos *et al.* 2013).

The data displayed on eicosenoic acid (Table 1) in genotypes/varieties of Indian mustard recorded that the variability of ecosenoic acid content ranged from 5.44-11.89% .The highest percentage of ecosenoic acid was recorded in genotype-KMR-18-407 and the lowest percentage of ecosenoic acid was recorded in genotype-TM-108-1.The similar findings were also reported by Chowdhury *et al*. (2010)reported that eicosanoic acid were present in small amount in mustard oil as compared to oleic and linoleic acid. Singh *et al.* (2007) showed the percentage variation of eicosenoic acid in mustard oil ranged from 4.89-12.99%. Ecosenoic acid, a precursor to prostaglandin, inhibits lipolysis and the conversion of ATP to cyclic-AMP in adipose tissues, *Brassica juncea* contains a higher concentration of this acid, which is hazardous to human health by Bergstrom S. (1966).

Erucic acid is a minor fatty acid, but it is vital for industrial uses such as lubricants, rubber manufacturing, additives, and oil paints. Results shown on erucic acid (Table 1) in genotypes/varieties of Indian mustard revealed that the value of range of variation of erucic acid was from 28.82-47.66%. The maximum value of erucic acid was exhibited in genotype-TM-108 and minimum value of erucic acid was found in two genotypes like KMR-17-6 and KMR-15-6. The genotype-KMR-18-406 is best for industrial purposes while genotype-KMR-16-307 is significantly best for nutrition point of view. The results achieved in the experimental findings were accordance with similar findings of Sawicka *et al*. (2020), Sharafi *et al*. (2015) who were reported the contents of erucic acid ranged from 41-46%. Similar finding were also reported by Abul-Fadl *et al.* (2011) and Singh *et al.* (2007) who were shown the contents of erucic acid was from 23.90- 37.89% and 41.36-53.50%, respectively. Some workers have reported that, by and large, due to higher intake of mustard oil having higher concentration more than 40% erucic acid may be cause of health problems like absorption, lipidosis in children and neurocardial fibrosis in adults Nolew (1981), Fatemi *et al*. (1980).

Polyunsaturated fatty acid-The data shown on linoleic acid (Table 1) indicated that the values ranged from 17.88-32.15%. The linoleic acid was highest in genotype-TM-106 obtaining 32.15% and lowest in genotype-KMR-18-406 having 17.88%. Genotype- TM-117 gave significantly 31.37% linoleic acid. The similar findings were also reported by the some workers such as Abul-Fadl *et al.* (2011)and Singh *et al.* (2007) who were reported the range of linoleic acid was from 12.37 to 21.36% and 10.51 to 18.00%.Sharafi *et al*. (2015)reported the linoleic acid content was 19% in mustard oil. It has a significant impact on human health, particularly in the prevention of cardiovascular disease (DVD), coronary heart disease, and cancer; as well as inflammatory, hypertension, diabetes type II, renal diseases, and Crohn's disease (Abedi *et al.,* 2014).

Mustard oil composition is rich in alpha-linolenic acid is the major fatty acid that has shown to exhibit anti-inflammatory properties and formation of prostaglandins which is essential for growth and development. The results of linolenic acid (Table 1) revealed that the range of variability from 11.82-19.85%. The maximum value was noted in genotype-KMR-16-304 and lowest was found in genotype-KMR-18-404. The similar findings were also reported by Singh *et al*. (2007) who revealed the percentage of linoleic acid was 4.92-15.02%. Kaushik and Agnihotri (2000)reported the range of linolenic acid was 11 to 20% in *Brassica juncea* L. The highest content of linolenic acid was 20% in *Brassica juncea* reported by Sharafi *et al*. (2015).

Iodine value**-** The iodine value indicates the degree of unsaturation of fat or oil. The data shown on iodine value (Table 1) indicated that the range of variation of iodine value was 114.43-131.71%. . The highest iodine value was obtained in genotype-TM-106 and lowest iodine value was found in

Table 2: Correlation studies among the various characteristic in Indian mustard of certain promising genotypes/varieties.

Characters	Oil content	16:0	18:0	18:1	18:2	18:3	20:1	22:1	I.V.
16:0	0.256711	-	-	-	-	-	-	-	-
18:0	-0.19862	-0.36992	-	-	-	-	-	-	-
18:1	-0.16531	0.028436	0.049648	-	-	-	-	-	-
18:2	-0.01371	0.191114	0.031303	0.211161	-	-	-	-	-
18:3	-0.13372	-0.17347	-0.21574	-0.23283	0.015309	-	-	-	-
20:1	-0.14053	-0.1264	0.058167	0.071125	-0.5491	-0.15107	-	-	-
22:1	0.217733	-0.16655	-0.01028	-0.6948	-0.68415	-0.12431	0.022235	-	-
I.V.	-0.09673	-0.09633	0.079784	0.091454	0.670959	0.624766	-0.35534	-0.61215	-
O.S.I.	0.108355	-0.09633	0.055743	-0.11423	-0.89598*	-0.42741	0.532041	0.703588	-0.85188*

Note: * = Significant, 16:0 = Palmitic acid,18:0 = Stearic acid, 18:1 = Oleic acid, 18:2 = Linoleic acid, 18:3 = Linolenic acid, 20:1 = Eicosenoic acid, 22:1 = Erucic acid, I.V. = Iodine value, O.S.I. = Oil stability index.

genotype-KMR-18-403.Variety-Ashirwad, Rohini and genotypes- KMR-16-307, KMR-16-306, KMR-16-304, KMR-18-402, KMR-15-6, KMR-15-5, KMR-16-5, KMR-17-6, TM-108-1, TM-106, TM-117 varied significantly. The range of variability of Iodine value of Indian mustard was almost conformity with the findings of Valentine *et al*. (2014) who reported the iodine value ranged from 102±0.07 to 113.8±0.01 in mustard oil. Sharifi *et al.* (2017) showed the iodine values were in BARI Sarisha-15 (72.50), BARI Sarisha-16 (70.60) and BARI Sarisha-17 (73.44).The oil stability index represents the storage quality of vegetable oils. The long storage quality is most beneficial for use of oils. Results represented (Table 1) on oil stability index indicated that the range of variation on oil stability index in Indian mustard oil was varied from 1.08-1.99. Genotype-KMR-16-308 gave the maximum value of OSI and genotype- TM-117 gave the minimum value of OSI. Genotypes-TM-108, KMR-18-404 showed significantly higher amount of oil stability index. The results of oil stability index was conformity with the findings of Chauhan *et al.* (2010)who were reported the oil stability index was 3.19 in variety-Parbati of Toria. Guimaraes *et al.* (2013)were also found the oil stability index was 0.79 in sesame oil and 5.25 in flaxseed oil.Correlation coefficient studies- The iodine value was inversely correlated with oil content, palmitic acid, erucic acid, and eicosenoic acid in genotypes/varieties of Indian mustard (Table 2). However, oil stability index was significantly negative correlated with linoleic acid and positively significant correlated with iodine value. Stearic acid was a negative and non-significant correlated with oil content and palmitic acid. Oleic acid and linoleic acid were non-significantly and negative correlated with oil content.

Linolenic acid was negatively and non-significantly correlated with oil content, palmitic acid, stearic acid and oleic acid, respectively. However linoleic acid was positive and non-significantly correlated with palmitate, stearate and oleate, respectively. Eicosenoic acid was non-significantly and negative correlated with oil content, palmitate, linolenate and linoleate, respectively. Erucic acid was a negative and non-significant correlation with palmitate, stearate, oleate, linolenate but it was positive or non-significant correlation with eicosenoic acid and oil content (Katavic *et al.,* 2001) and (Sasongko *et al.,* 2005) reported a significant negative correlation among oleic acid with erucic acid and linoleic acid. The non-significant correlation between oleic acid and linoleic was observed. Two separate biosynthetic pathways, which are genetically independent, are responsible for results on which converts oleic acid to linoleic acid and others which converts oleic to ecosenoic acid and ecosenoic acid to erucic acid (Krzymanski *et al.,* 1969).

Conclusion

The overall assessment of the selected genotypes/varieties of *Brassica juncea* was made on the basis of nutritional parameters and noted that, the genotype-KMR-15-6 followed by genotype- KMR-17-6 had the higher oil content, oleic acid content and low value of erucic acid alongwith the medium value of linoleic acid, linolenic acid, palmitic acid, stearic acid and eicosenoic acid. Consequently, when compared to other genotypes/varieties, genotype-KMR-16-308 had a high OSI.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abedi, E., & Sahhari M.A. (2014). Long-chain polyunsaturated fatty acid sources and evaluation of their nutritional and functional properties. *Food Sci. Nutr*.,*2*(5), 443-463.

Abul-Fadl, M.M., El-Badry, N., & Ammar M.S. (2011).Nutritional and chemical evaluation for two different varieties of mustard seeds. *World Applied Sciences Journal*,*15*(9), 1225-1233.

Ahmad, M., Khan, N.M.F., & Ahmad, M.M. (2012). Biochemical quality study of genetically diversified *brassica* genotypes. *Sarhad J. Agric*.,*28*(4), 599-602.

Ajala, A.S., & Adeleke S.A. (2014).Effect of drying temperatures on physicochemical properties and oil yield of African star apple (*Chrysophyllumalibidum*) seeds. *Global J. Eng. Design & Technology*,*3*(3), 12–16 (2014).

Anonymous. (2020).*Official Methods of Analysis*, 21st Edition, Association of Official Analytical Chemists: Washington, Dc.

Aremu, M.O., Olaofe, O., & Akintayo E.T. (2006). Chemical composition and physicochemical characteristics of two varieties of bambara groundnut (*Vigna subterrenea*) flours. *J. Applied Sciences*,*6*(9), 1900–1903.

Bergstrom, S. (1966). The Prostaglandins. *Recent Progr. Harmone Res. 22*, 153-175.

Carpenter, D.L., Lehman, J., Manon, T.S.,& Slover H.T. (1976).Lipid composition of selected vegetable oils. *J. Am. Oil Chem. Soc*.,*53*(12), 713-718.

Carta, G., Murru, E., Banni, S., & Manca C. (2017). Palmitic acid: Physiological role, Metabolism and Nutritional implication, *Front Physiol*., *8*, 902.

Chauhan J.S., Kumar S. (2011). Assessment of oil and seed meal quality parameters of rapeseed mustard group of crops. *Indian J. Agricul.*, *Sci.,* 81(2), 140–144.

Chauhan, J.S., Kumar, S.,& Singh, K.H. (2010). Oil and seed meal quality indices of Indian rapeseed-mustard varieties. *J. Plant Biochem. Biotechnol*.,*19*(1), 83–86.

Chowdhury, M.F.N., Shahjahan, M., Ahmed, K.U., Nuruddin, M.M., & Hosen M. (2010).Study on fatty acid composition, oil and protein of different varieties and advanced line of mustard and rapeseeds. *Bangladesh Research Publication Journal*,*4*(6), 82-86.

Dar, Z.A., Wan, S.A., Ahmad, G., Sheikh, F.A., Ishfaq, A., Razvi, M., & Habib M. (2011). G×E Interaction for seed yield and oil content in brown sarson (*Brassica rapa*L.) under temperate conditions. *Cruciferae Newsletter*,*30*, 25-26.

Fatemi, S.H.,& Hammond, E.G. (1980). Analysis of oleate, linoleate and linolenate hydroperoxides in oxidized ester mixtures. *Lipids*, *15*(5), 379-385.

Fritsch, K., & Whelan, J. (2013). Linoleic Acid, *Advances In Nutrition*,*4*(3), 311-312.

Guimaraes, R.D.A., Macedo, M.L.R., Munhoz, C.L., Filiu, W., Viana, L.H.,Nozaki, V.T., & Hiane P.A. (2013). Sesame and faxseed oil: nutritional quality and effects on serum lipids and glucose in rats. *Food Science and Technology*,*33*(1), 209-217.

Gupta, V., Pratap, V., Bhadauria, S., Agarwal R.L. (2011).Effect of nitrogen and split doses of potassium on quality aspects of Brassica species. *African Journal of Agricultural Research*,*6*(2), 285-288.

Jamieson G. (1943).*Vegetables Fats and Oils*, Reinhold Publishing Corporation: New York, USA,*21*(6),262-280.

Katavic, V., Friesen, W., Barton, L.D., Gossen, K.K., Giblin, E.M., &Luciw, T. (2001).Improving erucic acid content in rapeseed through biotechnology: What can the Arabidopsis Fae1 and yeast Slc1-1 genes contribute, *Crop Science*,*41*,739–747.

Kaushik, N., &Agnihotri, A. (2000). Glc Analysis of Indian rapeseed-mustard to study the variability of fatty acid composition. *Biochemical Society Transaction*,*28*(6), 581-583.

Kelly, F.D., Sinclair, A.J., Mann, N.J., Turner, A.H., Abedin, L., & Li D. (2001).A stearic acid rich diet improves thrombogenic and atherogenic risk factor profiles in healthy males, *European Journal of Clinical Nutrition*,*55*(2), 88-96.

Krzymanski, J., &Downey, R.K. (1969). Inheritance of fatty acid composition in winter forms of rapeseed, *Brassica napus*. *Canadian Journal of Plant Science*,*49*(3), 313–319.

Luddy, F.E., Barfore, R.A., Berb, S.F., & Paul M.J. (1968).A rapid and quantitative procedure for the production of methyl esters of butter, oil and other fats. *J. Am. Chem.* Soc.,*45*(8), 549-552.

Nolew, G.A. (1981). Biological evaluation of hydrogenated rapeseed oil. *Journal of American Oil Chemist's Society*., *58*(1), 31-37.

Priyamedha, S., Singh, B.K., Ram, B., Kumar, A., Singh, V.V., Meena, M.L., &Singh, D. (2014). Development and evaluation of double low quality lines in Indian mustard (*Brassica Juncea L.* Czern & Coss). *Sabrao Journal of Breeding and Genetics*., *46*(2), 274-283.

Rai, G.K., Bagati, S., Rai, P.K., Rai, S.K., &Singh, M. (2018). Fatty acid profiling in rapeseed mustard (*Brassica species*). *Int. J. Curr. Microbiol. App. Sci.*,*7*(5), 148-157.

Rangaswamy, R. (2016).*A Textbook of Agriculture Statistics* Published by new age international publisher, New Delhi.

Sales-Campos, H., Desouza, P.R., Peghini, B.C., Da Silvajs, J.S., Cardoso, C.R. (2013). An overview of the modulatory effects of oleic acid in health and disease. *Mini-Reviews In Medicinal Chemistry*, *13*(2), 2001-2010.

Sasongko, N.D., & Möllers C. (2005). Toward increasing erucic acid content in oil seed rape (*Brassica napus* L.) through the combination of genes for high oleic acid. *Journal of The American Oil Chemists Society*, *82*(6), 445–449.

Sawicka, B., &Kotiuk, E. (2007). Mustard species as multi-functional plants. *Acta Scientiarum Polonorum Agricultur*,*6*(2), 17-27.

Senyilmaz, D., Virtue, S., Xu, X., Tan,C.Y., Griffin, J.L., Miler, A.K., Vidal-Puig, A., &Teleman, A.A. (2015). Regulation of mitochondrial morphology and function by stearoylation of Tfr1. *Nature*,*525*(7567), 124-128.

Sharafi, Y., Majidi, M.M., Goli, S.A.H., & Rashidi, F. (2015). Oil content and fatty acids composition in *Brassica* species. *International Journal of Food Properties*,*18*(10), 2145-2154.

Singh L., Prasad R.N. (2007). Nutritional Quality Evaluation Of Some Genotypes Of Toria. *Indian J. Agric. Biochem*,*20*, 69-70.

Singh S., Singh, R.P., Singh, H.K., &Kumar, K. (2011). Fatty acid composition of Indian mustard (*Brassica juncea* L. Czern & Coss). *Cruciferae Newsletter*,*30*, 23-24.

Stark, A. H., Michael, A., Crawford., & Reifen, R.(2008). Update on alpha-linolenic acid. *Nutrition Reviews*,*66*(6), 326-332.

Sutariya, D.A., Patel, K.M., Bhadauria, H.S., Vaghela, P. O., Prajapati, D. B., Parmar S. K. (2011). Genetic diversity for quality traits in Indian mustard (*Brassica juncea L.*). *Journal of Oilseed Brassica*,*2*(1), 44-47.

Valentine, R.S., Kumar, V.M., & Devasena, T. (2014).Selected rheological characteristics and physicochemical properties of vegetable oil affected by heating. *Int. J. Of Food Properties*, *19*(8), 1852-1862.

Wendlinger, C., Hammann, S., & Vatter, W. (2014). Various concentration of erucic acid in mustard oil and mustard. *Food Chemistry*, 153, 393-397.

Publisher's Note: ASEA remains neutral with regard to jurisdictional claims in published maps and figures.