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Comparative Study on the Oil Content and Fatty Acids Profile among Some *Brassica rapa* L. Genotypes

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ABSTRACT

The study was carried out at Biochemistry, Agricultural Chemistry and Environmental Science laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from March, 2020 to September, 2021 to estimate oil content and fatty acids composition of some *Brassica rapa* L. genotypes. The experiment was laid out in a completely randomized design with three replications and consisted of four genotypes viz., BARI Sarisha-14, Brown Special, Yellow Special, Tori-7 and their F_1s. Result revealed that the oil content ranged from 34.25-45.05% among the studied genotypes. The parent, Yellow Special contained the highest amount of oil (45.05%) and Brown Special contained the lowest amount (39.48%), while among the F_1s, (Brown Special×Yellow Special) contained the highest amount (39.04%) and (BARI Sar-14×Brown Special) contained the lowest amount (34.25%). The major saturated and unsaturated fatty acids content ranged from 3.92-5.42% and 92.39-93.50% respectively. The parent, Brown Special and the F_1- (BARI Sar-14×Brown Special) contained the highest amount of unsaturated fatty acids (92.81%) and (93.50%) respectively, while the parent Yellow Special and the F_1- (Brown Special×Tori-7) contained the lowest amount of saturated fatty acids (3.96%) and (3.92%) respectively. The highest poly unsaturated fatty acids containing parent was Tori-7 (16.98%) and F_1 was Yellow Special×Tori-7 (19.27%). The erucic acid content ranged from 44.97- 54.56%. Among the parents, Tori-7 and among the F_1s-Yellow Special×Tori-7 contained the lowest amount of erucic acid (44.97%) and (45.37%) respectively. Therefore, the parents and F_1s with high level of poly unsaturated fatty acids and low level of erucic acid could be selected for further development of these trait.

KEYWORDS: *Brassica rapa*, oil, unsaturated fatty acids, erucic acid

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1. INTRODUCTION

Brassica oilseed have become the third most important source of edible oils in the world (Cartea et al., 2019) and have preventive nutritional value including tocopherols and other vitamins (Dhanik et al., 2018). Moreover, it is used in a large scale in food, chemical, medicine and engineering industries (Swati et al., 2015) and recommended to use for massages and in diabetes curing (Sarkar et al., 2016). *Brassica rapa* oils has high medicinal values including both anticancer and antioxidant properties (Jan et al., 2018). Apart from its medicinal value, it also has high nutritional values as it contains 38-40% protein with a complete amino acid profile (Ullah et al., 2017) and is a carrier of fat-soluble vitamins (Rashid, 2013). But the oil quality is determined by both nutritional and functional factors, which in turn, are mainly determined by their fatty acid profiling (Ko et al., 2017 and Niemann et al., 2020). Basically, fatty acids of oils is the main factor responsible for oxidation and also for the formation of undesirable compounds or flavours (Arslan et al., 2015 and Fernandez Cedi et al., 2012). Bhattacharya et al. (2012) reported that Brassica species are enriched in various saturated and unsaturated fatty acids. The saturated fatty acids includes palmitic acid whereas, the unsaturated fatty acids are either monounsaturated (erucic and oleic acid) or polyunsaturated (linolenic and linoleic acid) which are nutritionally important. Mekki (2013), Nath et al. (2016) and Ostrikov et al., (2020) also supported this findings and reported that it is also free from cholesterol. Amir et al. (2012), Mubashir et al. (2012) and Jeet (2018) reported that mustard and rapeseed oils are good for health as they have lowest levels of saturated fatty acids and balanced amount of unsaturated fatty acids. Saturated fatty acids increases the risk of cardiovascular diseases (Sawicka et al., 2020). Though rapeseed and mustard oil have many advantageous properties but it also contains higher amount of toxic erucic acid (Priyamedha et al., 2014, Meena and Talekar, 2022, Mitiku and Yali, 2022). Erucic acid is highly toxic in nature as it damages cardiac muscle of animals and can pose serious health risks (cardiovascular issues) to us (Eskin, 2016 and Srivastava et al., 2023). Anonymous (2016) declared that, oils with 20 to 40% erucic acid is not permitted for use as it may cause nutritional deficiencies and cardiac lesions in test animals. The erucic acid content in rapeseed and mustard oil ranged from 50 to 55% (Priyamedha et al., 2014, Sharafi et al., 2015, Kumar et al., 2018 and Mitiku and Yali, 2022) and *Brassica rapa* has oil and erucic acid content 31% and 41-50% respectively (Yousef et al., 2015). The fatty acid composition of presently cultivated *Brassica rapa* varieties in Bangladesh are also not acceptable to international standards for its very high erucic acid content though higher amount of erucic acid is industrially important. Therefore, it is very essential to develop new genotypes through efficient breeding programmes to maintain international standard (Meena and Talekar, 2022) which require a complete fatty acid profiling of the genotypes used for breeding purposes (Mitiku and Yali, 2022). Considering this, the present study had carried out to evaluate the fatty acid composition of some *Brassica rapa* genotypes and their F_1s. Which will give a valuable information in breeding directed towards the development of new genotypes with low as well as high levels of erucic acid for edible and commercial purposes, respectively.

2. MATERIALS AND METHODS

2.1. Location, period and year of experiment

The experiment was conducted at Biochemistry, Agricultural Chemistry and Environmental Science laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from March/2020 to September/2021 to estimate the oil content and fatty acids composition of some *Brassica rapa* L. genotypes.

2.2. Experimental materials

The *Brassica rapa* parents materials were collected from Bangladesh Agriculture Research Institute (BARI) and Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University which include P_1 (BARI Sarisha-14), P_2 (Brown Special), P_3 (Yellow Special) and P_4 (Tori-7). Where, selection criteria for P_1 and P_3 were for yield, P_2 for yield and short duration and P_4 for short duration and low erucic acid.

2.3. Experimental design

The experiment was laid out in a completely randomized design with three replications and consisted of four parents and their F_1s. The parent materials were subjected for crossing in a 4×4 half di-allel fashion. Crossing was made by hand pollination in desirable genotypes to make the desired combinations. After that oil quantity and quality of the parents and their F_1s genotypes were estimated.

2.4. Determination of 1000 grain weight

The mass was determined by randomly selecting 100 samples and weighing in an electronic balance of 0.001 g sensitivity. The weight was then converted into 1000 seed mass.

2.5. Determination of dry matter content

Moisture content of mustard sample was determined by conventional method. Empty aluminum moisture dish was weighted (W_1) and 2.5 g sample was taken in a moisture dish and weighted (W_2). The sample was spread evenly and placed without lid in oven and dried samples overnight at 100°C. The dishes were transferred to desiccators to cool. Aluminum dish was weighed after cooling (W_3).

% Dry matter={(W_3–W_1)/(W_2–W_1)}×100

2.6. Determination of moisture

% Moisture=(100–Dry matter content)

2.7. Extraction and estimation of oils

The seeds were collected from four parents and their cross materials obtained from 4×4 half di-allel fashion. The extraction and estimation of oil% were done following Sumon et al. (2021) with some modifications. Briefly, oven dried seeds were weighed out into an extraction thimble. The thimble was placed into the soxhlet and 150-200 ml petroleum ether was added to the soxhtet flask, then it was connected to holder and condenser. Soxhlet flask was placed on a round bottle flask on hot water bath and distilled at 80°C temperature for eight hours. After extraction it was turned off and allowed to cool. After distillation the extraction thimble was removed and allowed to air dry for 30-40 minutes, the thimble was weighed out. Then the oil content was determined by the procedure described by Hughes (1965).

% Crude fats/Oil (on a dry weight basis)=Weight of thimble and sample before extraction-Weight of thimble and sample after extraction/Weight of sample before extraction×100

2.8. Estimation of fatty acid composition by gas chromatography

2.8.1. Preparation of oil samples

After the extraction procedure, the solvents were evaporated under vacuum, and the samples were subsequently stored at 4°C.

2.8.2. Methylation of oil sample for FAME (Fatty Acid Methyl Ester) synthesis

Two-step methylation procedure was followed. Oils obtained after the extraction of samples were converted to the corresponding FAMEs according to O'Fallon et al. (2007). In this procedure, 40 µl of extracted oil was placed into 10 mL centrifuge tubes to which 0.7 ml of potassium hydroxide (10 M) solution and 5.3 ml of methanol were added. The reaction was performed at 55°C for 1.5 h with mixing for 5 s every 20 min. After cooling to room temperature, 0.58 ml of sulfuric acid (10 M) solution was added and the reaction was continued at 55°C for 1.5 h with mixing for 5 s every 20 min. After cooling to room temperature, 3 ml of n-hexane was added and mixed for 5 min. Subsequently, the tubes were centrifuged for 5 min and the extracts were removed for GC analysis.

2.8.3. Analysis of FAME products by GC (Gas chromatography)

The fatty acids composition of the FAMEs from oil was determined using an Agilent 6820 Gas Chromatograph equipped with a capillary column (hp-innowax, Agilent, 100×0.25 mm^2, i.d. 0.20 µm), a flame ionization detector and split injection port. The initial oven temperature was 200°C, which was held for one min, subsequently increased to 230°C at 1.5°C min^{-1} and then held for one min. The injector was set at 250°C, and the detector at 280°C. Nitrogen was used as the carrier gas at a flow rate of 1 ml/min. The split ratio was 50:1, and the sample size was 1 µl.

2.9. Statistical analysis

Significance of differences among means was determined by the Duncan Multiple Range (DMR) test at $p\leq5\%$. The computer software MSTAT-C was used to perform the statistical analysis.

3. RESULTS AND DISCUSSION

3.1. 1000 seeds weight

A statistically significant variation was observed for 1000 seeds weight, moisture, dry matter, oil content, oil cake and dry weight of cake among the studied genotypes. The thousand seeds weight ranged from 2.82 to 4.62 g. Among the parents the highest thousand seeds weight was recorded in Yellow Special (4.62 g) and it was lowest in Tori-7 (2.82 g) while in F_1 generation the highest thousand seeds weight was recorded in BARI Sar-14 × Brown Special (4.25 g) and the lowest was in Brown Special×Tori-7 (2.98 g) (Table 1). The present values were consistent with the results reported by Banga et al. (2013) and Chowdhury et al. (2014) who reported that the thousand seed weight ranged from 2.5 to 4.9 g in different Bangladeshi mustard varieties and advanced lines. The present values also remained within the range (3.33 to 4.53 g) and (3.50 to 5.53 g) reported by Karmokar (2020) and Ferdous (2021) respectively but in some cases the result was higher than the reported value of Ullah (2020) who found that thousand seed weight varies from 2.50 to 3.63 g. This is might be due to larger seed size as seed weight varied with their size and shape.

3.2. Moisture and dry matter content

The moisture content ranged from 4.50 to 6.46%. The highest moisture content (6.46%) was observed in Tori-7 while the lowest moisture content (4.50%) was found in Yellow Special. In F_1 generation, the highest moisture content (6.30%) was observed in Brown Special×Tori-7 while the lowest moisture content (4.85%) was found in BARI Sar-14×Brown Special (Table 1). The results of the moisture content remained within the findings of Islam et al. (2020b) who found 4.3 to 6.60% in different Bangladeshi mustard varieties and advanced lines but significantly lower than that of Sarker et al. (2015) and Mahmud et al. (2012), where they reported that moisture content of mustard ranged from 9.20±0.5 to 9.73±0.6% and 8.3±0.2% respectively. These may be influenced by different level of sun drying after harvesting. Significantly highest dry matter content was recorded in Yellow Special (95.50%) and the lowest was in Tori-7 (93.54%) which was significantly lowest among all the genotypes. In F_1 generation, the highest dry matter content (95.15%) was observed in BARI Sar-14×Brown Special while the lowest (93.70%) was found in Brown Special×Tori-7 (Table 1). The result for dry matter content slightly differed from Islam et al. (2020b) who found 94.90 to 95.70% dry matter in different Bangladeshi mustard varieties and advanced lines. These variations might be due to environmental factor, soil and crop management practices.

3.3. Oil content

The oil contents ranged from 34.25 to 45.05%. Among the parents Yellow Special contained the highest amount of oil (45.05%) and Brown Special contained the lowest amount (39.48%). In the F_1 generations Brown Special×Yellow Special contained the highest amount of oil (39.04%) and BARI Sar-14×Brown Special contained the lowest amount (34.25%) (Table 1). All the F_1s contained the lower amount of oils than both of their parents (Table 1). More or less similar result was reported by Arif et al. (2012), Mumtaz et al. (2014) and Sharafi et al. (2015) who found 35.67 to 45.87%, 35.00 to 46.00% and 21.00 to 45.00% oils respectively in different rapeseed and mustard variety but the result exceeded the findings of Gadei et al. (2012) and Islam et al. (2020b) who reported that the oil content ranged from 28.00 to 32.00% and 38.74 to 40.55% respectively. These variations might be due to biological and environmental factor or for soil and crop management practices.

Table 1: Proximate analysis of 1000 seeds weight, moisture, dry matter, oil, oil cake content and dry weight of cake of selected *Brassica rapa* and their F_1s genotypes

Genotypes		1000 seeds weight (g)	Moisture (%)	Dry matter (%)	Oil content (%)	Oil cake (%)	Dry weight of cake (%)
Parents	(P_1) BARI Sar-14	3.35^g	5.95^c	94.05^h	41.25^c	58.75^h	53.98^h
	(P_2) Brown special	3.62^e	5.68^e	94.32^f	39.48^d	60.52^g	55.70^g
	(P_3) Yellow special	4.62^a	4.50^j	95.50^a	45.05^a	54.95^j	50.30^i
	(P_4) Tori-7	2.82^i	6.46^a	93.54^j	41.31^b	58.69^i	53.94^h
F_1s	BARI Sar-14×Brown special	4.25^b	4.85^i	95.15^b	34.25^j	65.75^a	60.65^a
	BARI Sar-14×Yellow special	3.92^d	5.30^f	94.70^e	37.71^g	62.29^d	56.58^d
	BARI Sar-14×Tori-7	4.11^c	5.05^g	94.95^d	38.57^f	61.43^e	56.41^e
	Brown special×Yellow special	4.24^b	4.95^h	95.05^c	39.04^e	60.96^f	56.13^f
	Brown special×Tori-7	2.98^h	6.30^b	93.70^i	35.64^i	64.36^b	59.31^b
	Yellow special×Tori-7	3.44^f	5.85^d	94.15^g	36.19^h	63.81^c	58.91^c
	Maximum	4.62	6.46	95.50	45.05	65.75	60.65
	Minimum	2.82	4.50	93.54	34.25	54.95	50.30
	Mean	3.74	5.49	94.51	38.85	61.15	56.19
	CV%	0.55	0.86	0.05	0.08	0.05	0.06
	LSD	0.03	0.08	0.08	0.05	0.05	0.05

Figure in a column followed by a common letter do not differ significantly at (p=0.05) level by DMRT

3.4. Oil cake content and dry weight of cake

Oil cake content and dry weight of cake ranged from 54.95 to 65.75% and 50.30 to 60.65% respectively. Among the parents, Brown Special contained the highest amount of oil cake (60.52%) and dry weight of cake (55.70%) while the lowest value was observed in Yellow Special (54.95%) and (50.30%) respectively. In F_1 generation, the highest amount of oil cake (65.75%) and dry weight of cake (60.65%) was observed in BARI Sar-14×Brown Special and the lowest value was recorded in Brown Special×Yellow Special (60.96%) and (55.13%) respectively (Table 1). The present values for oil cake and dry weight of cake were higher than the reported value of Chowdhury et al. (2014) and Islam et al. (2020b) who found 58.14 to 59.95% and 59.45 to 60.26% oil cake in different varieties and lines of rapeseed and mustard.

3.5. Fatty acids composition

Here, the most common and important saturated and unsaturated fatty acids were counted. Significant variations were observed in different saturated and unsaturated fatty acids contents among the parents and their F_1 generations. It ranged from 3.92 to 5.42% and 92.39 to 93.50% respectively

(Figure 1). Among the parents Brown Special contained the highest amount of unsaturated fatty acids (92.81%) of which 77.22% was monounsaturated and 15.59% polyunsaturated and Tori-7 contained the lowest (92.39%) unsaturated fatty acids of which 75.41% monounsaturated and 16.98% polyunsaturated while Yellow Special contained the lowest amount of saturated fatty acids (3.96%) and Tori-7 contained the highest amount (5.96%) (Figure 1 and 2). In F_1 generations the highest amount of unsaturated fatty acids (93.50%) was recorded in BARI Sar-14×Brown Special, of which 79.04% was monounsaturated and 14.46% was polyunsaturated. Which was higher than both of its parents while the lowest amount of saturated fatty acids

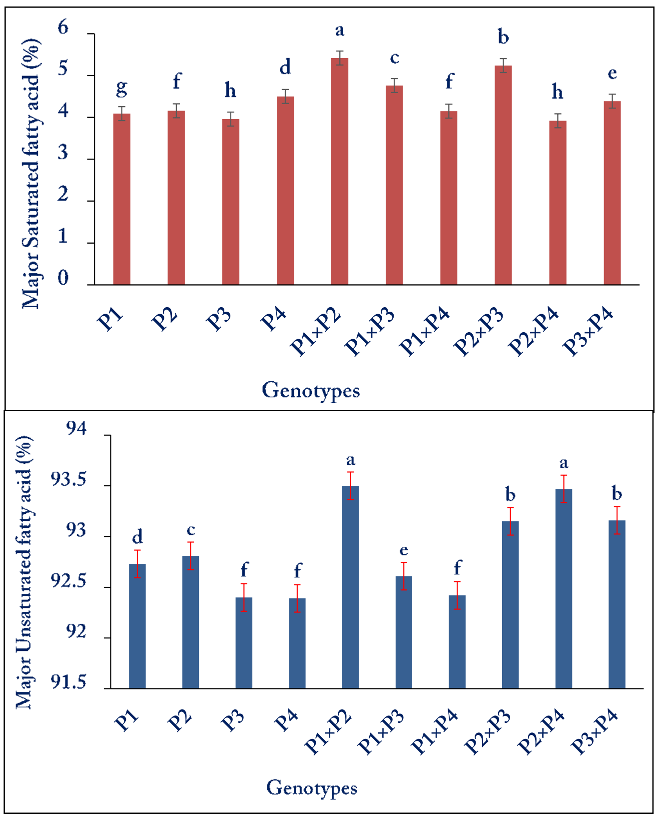

Figure 1: Major saturated and unsaturated fatty acid contents of selected *Brassica rapa* and their F_1 genotypes; Where, P_1: BARI Sar-14; P_2: Brown special; P_3: Yellow special; P_4: Tori-7

(3.92%) was recorded in Brown Special×Tori-7 which was lower than both of its parents. However, the highest amount of monounsaturated fatty acids (79.16%) was recorded in Brown Special×Yellow Special and polyunsaturated fatty acids (19.27%) was recorded in Yellow Special×Tori-7 (Figure 1 and 2). Other remaining saturated and unsaturated fatty acids were found in very negligible amounts (1.08 to 3.64%) (Figure 3). More or less similar result was reported by Fadl et al. (2011) and Karmokar (2020) for unsaturated fatty acids where it ranged from 91.06 to 91.55% and 90.79 to 93.08% respectively but lower for saturated fatty acids

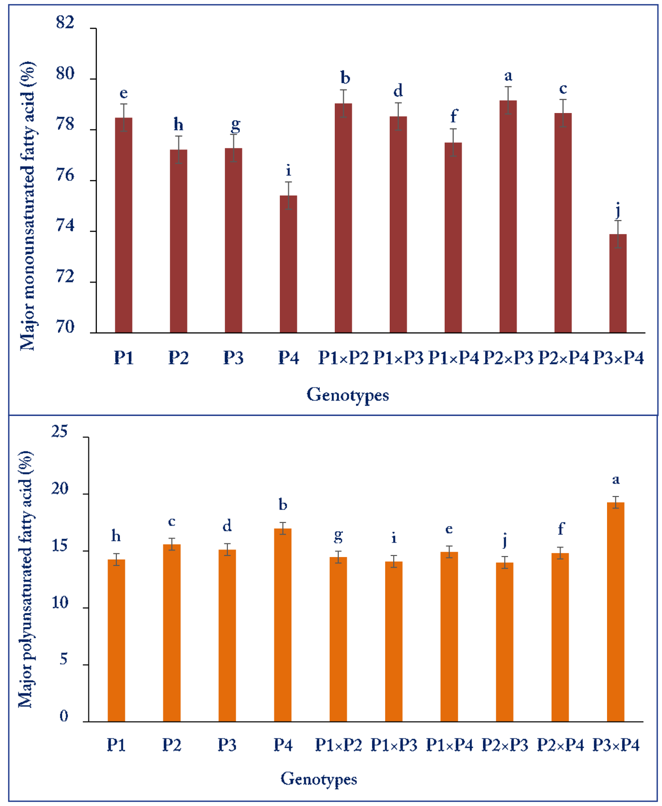

Figure 2: Major mono and poly unsaturated fatty acid contents of selected *Brassica rapa* and their F_1 genotypes; Where, P_1: BARI Sar-14; P_2: Brown special; P_3: Yellow special; P_4: Tori-7

where they reported it ranged from 8.45 to 8.94% and 6.92 to 9.22% respectively.

3.5.1. Saturated fatty acids composition

3.5.1.1. Palmitic and stearic acid content

The palmitic acid contents ranged from 1.76 to 2.10%. Among the parents Yellow Special contained the lowest amount of palmitic acid (1.76%) and Tori-7 contained

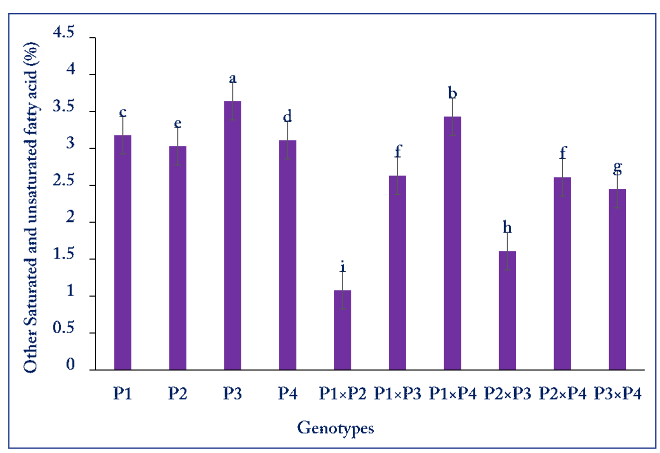

Figure 3: Other saturated and unsaturated fatty acid contents of selected *Brassica rapa* and their F_1 genotypes; Where, P_1: BARI Sar-14; P_2: Brown special; P_3: Yellow special; P_4: Tori-7

the highest amount (2.06%). In the F_1 generations Brown Special×Yellow Special contained the lowest amount (1.80%) which was lower than one of its parent Brown Special while BARI Sar-14×Yellow Special contained the highest amount (2.10%) (Table 2). The stearic acid contents ranged from 0.92 to 1.38%. Among the parents Yellow Special contained the lowest amount (1.10%) and Tori-7 contained the highest amount (1.27%). In the F_1 generations Brown Special×Yellow Special contained the lowest amount (0.92%) which was lower than both of its parents and BARI Sar-14×Yellow Special contained the highest amount (1.28%) which was higher than both of its parents (Table 2). The palmitic acid content remained within the findings of Karmokar (2020) and Islam et al. (2020a) who reported that palmitic acid contents ranged from 1.68 to 2.68% and 1.77 to 3.44% respectively in different rapeseed and mustard variety while for stearic acid the results exceeded the findings of Karmokar (2020) who reported 0.49 to 0.74% but remained within the findings of Islam et al. (2020a) who reported 0.00 to 1.77% stearic acid in different mustard variety but Ko et al. (2017) noticed 20.40% stearic acid in his experiment. Therefore, the parents and their F_1s with the low level of palmitic and stearic acids could be selected for further breeding purpose.

3.5.1.2. Arachidic and lignoceric acids content

The arachidic acids contents ranged from 0.75 to 0.96%. Among the parents Tori-7 contained the highest amount (0.96%) but this amount was statistically similar with rest of the parents. In the F_1 generations both Brown Special×Yellow Special and Brown Special×Tori-7 contained the lowest amount (0.75%) which was lower than both of their parents (Table 2). The lignoceric acids contents ranged from 0.18 to 1.77%. Brown Special contained the lowest amount (0.18%) among the parents and in F_1 generations Yellow Special×Tori-7 contained the lowest amount (0.25%) which was statistically similar with both of its parents (Table 2). The result for arachidic acid was much lower than the findings of Karmokar (2020) who reported that it ranged from 3.61 to 6.60% but remained within the findings of Islam et al. (2020a) who reported 0.74 to 4.74% arachidic acids in different rapeseed and mustard variety. Lignoceric acid content exceeded the findings of Karmokar (2020) who reported, it was 0.19 to 0.35% in different *Brassica rapa* genotypes. Therefore, the parents and their F_1s with the low level of arachidic and lignoceric acids could be selected for further breeding purpose.

3.5.2. Unsaturated fatty acids composition

3.5.2.1. Monounsaturated fatty acids

3.5.2.1.1. Palmitoleic, oleic, octadecenoic and eicosenoic acids content

The palmitoleic acid was found in very negligible amount

Table 2: Major saturated fatty acid compositions of *Brassica rapa* parent materials and their F_1s genotypes

Genotypes		Saturated fatty acids (%)			
		Palmitic acid (C16:0)	Stearic acid (C18:0)	Arachidic acid (C20:0)	Lignoceric acid (C24:0)
Parents	(P_1) BARI Sar-14	1.82[ef]	1.20[c]	0.87[c]	0.20[g]
	(P_2) Brown special	2.00[abcd]	1.12[d]	0.86[c]	0.18[g]
	(P_3) Yellow special	1.76[f]	1.10[d]	0.86[c]	0.24[ef]
	(P_4) Tori-7	2.06[ab]	1.27[b]	0.96[a]	0.21[fg]
F_1s	BARI Sar-14×Brown special	2.04[abc]	1.05[e]	0.85[c]	1.48[b]
	BARI Sar-14×Yellow special	2.10[a]	1.38[a]	0.92[b]	0.36[c]
	BARI Sar-14×Tori-7	1.90[de]	1.09[d]	0.86[c]	0.30[d]
	Brown special×Yellow special	1.80[ef]	0.92[g]	0.75[d]	1.77[a]
	Brown special×Tori-7	1.94[cd]	0.97[f]	0.75[d]	0.26[e]
	Yellow special×Tori-7	1.97[bcd]	1.26[b]	0.91[b]	0.25[e]
	Minimum	1.76	0.92	0.75	0.18
	Maximum	2.10	1.38	0.96	1.77
	Mean	1.94	1.14	0.86	0.53
	CV%	3.49	1.76	2.15	3.66
	LSD	0.12	0.03	0.03	0.03

Figure in a column followed by a common letter do not differ significantly at (p=0.05) level by DMRT

and ranged from 0.15 to 0.21%. Among the parents Yellow Special contained the highest amount (0.21%) and in F_1 generations BARI Sar-14×Brown Special and BARI Sar-14×Tori-7 both contained the highest amount (0.20%) which was statistically similar with both of their parents (Table 3). The oleic acid contents ranged from 11.61 to 13.58%. Among the parents BARI Sar-14 contained the highest amount (13.58%) followed by Brown Special (12.83%) while in the F_1 generations Brown Special×Yellow Special contained the highest amount (12.78%) which was higher than one of its parent (Yellow Special) and the lowest amount (11.61%) was estimated in BARI Sar-14×Tori-7 (Table 3). Octadecenoic acid contents ranged from 11.31 to 17.42%. Among the parents Tori-7 contained the highest amount (17.42%) followed by Brown Special (14.49%). In the F_1 generations Yellow Special×Tori-7 contained the highest amount (16.34%) which was higher than one of its parent (Yellow Special) (Table 3). The eicosenoic acid ranged from 0.26 to 0.41%. Among the parents Tori-7 contained the highest (0.41%) followed by Brown Special (0.40%). In the F_1 generations both BARI Sar-14×Tori-7 and Brown Special×Tori-7 contained the highest amount (0.37%) for the first one it was higher than one of its parent (BARI Sar-14) and for last one it was lower than it's both parents (Table 3). The result for palmitoleic acid was more or less similar with the findings of Amir et al. (2012) and Islam et al. (2020a) who reported less than 1.00% palmitoleic acid in different rapeseed and mustard variety while for oleic acid the results matched with Fadl et al. (2011), Chauhan and Kumar (2011) and Mubashir (2012), Karmokar (2020) and Islam et al. (2020a) who reported 19.08 to 20.24%, 13.60 to 32.20%, 12.00%, 11.27 to 15.16% and 9.03 to 18.56% oleic acid in different rapeseed-mustard oil respectively. For eicosenoic acids Islam et al. (2020a) also reported less than 1.00% in different rapeseed and mustard variety.

3.5.2.1.2. Erucic acid contents

The erucic acids contents ranged from 44.97 to 54.56%. Among the parents, Tori-7 had the lowest amount (44.97%) preceded by Brown Special (49.32%) while BARI Sar-14 contained the highest amount (51.34%) followed by (51.26%) in Yellow Special. In the F_1 generations the lowest amount (45.37%) was recorded in Yellow Special×Tori-7 which was much lower than one of its parent (Yellow Special) and slightly higher than its other parent (Tori-7) and the highest (54.56%) was recorded in Brown Special×Yellow Special followed by (53.19%) in Brown Special×Tori-7 (Figure 4). The results for erucic acid content remained within the findings of Mubashir (2012), Ko et al. (2017), Karmokar (2020) and Islam et al. (2020a) who observed 48.00 to 59.00%, 42.00%, 45.30%, 54.08 to 60.75% and 41.11 to 50.67% erucic acids respectively in different rapeseed-mustard oil.

Table 3: Major monounsaturated fatty acid compositions of selected *Brassica rapa* and their F_1s genotypes

Genotypes		Monounsaturated fatty acids (%)			
		Palmitoleic acid (C16:1)	Oleic acid (C18:1, c9)	Octadecenoic acid (C18:1, t9)	Eicosenoic acid (C20:1)
Parents	(P_1) BARI Sar-14	0.17[bc]	13.58[a]	13.05[g]	0.34[cd]
	(P_2) Brown special	0.18[abc]	12.83[b]	14.49[c]	0.40[ab]
	(P_3) Yellow special	0.21[a]	12.29[e]	13.18[f]	0.34[cd]
	(P_4) Tori-7	0.17[bc]	12.44[d]	17.42[a]	0.41[a]
F_1s	BARI Sar-14×Brown special	0.20[ab]	12.42[d]	13.64[d]	0.36[c]
	BARI Sar-14×Yellow special	0.15[c]	12.14[f]	13.52[e]	0.26[e]
	BARI Sar-14×Tori-7	0.20[ab]	11.61[h]	13.64[d]	0.37[bc]
	Brown special×Yellow special	0.19[ab]	12.78[c]	11.31[i]	0.32[d]
	Brown special×Tori-7	0.19[ab]	12.12[f]	12.79[h]	0.37[bc]
	Yellow special×Tori-7	0.15[c]	11.68[g]	16.34[b]	0.35[cd]
	Minimum	0.15	11.61	11.31	0.26
	Maximum	0.21	13.58	17.42	0.41
	Mean	0.18	12.39	13.94	0.35
	CV%	10.63	0.17	0.17	5.46
	LSD	0.03	0.03	0.04	0.03

Figure in a column followed by a common letter do not differ significantly at (p=0.05) level by DMRT

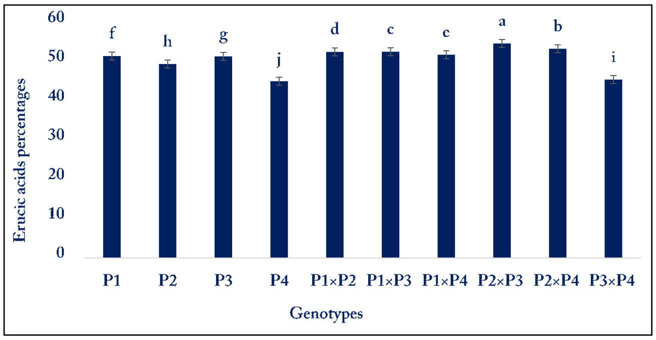

Figure 4: Erucic acid contents of selected *Brassica rapa* and their F_1 genotypes. (Where, P_1: BARI Sar-14, P_2: Brown special, P_3: Yellow special and P_4: Tori-7)

3.5.2.2. Polyunsaturated fatty acids

3.5.2.2.1. Linoleic, linolenic and arachidonic acids content

The linoleic acids contents ranged from 6.70 to 9.68%. Among the parents Yellow Special contained the highest amount (8.16%) followed by Brown Special (7.58%) while BARI Sar-14 contained the lowest amount (7.14%). In F_1 generations Yellow Special×Tori-7 contained the highest amount (9.68%) which was higher than both of its parents followed by (7.84%) in Brown Special×Yellow Special and the lowest amount (6.70%) was recorded in BARI Sar-14×Brown Special (Table 4). The linolenic acids contents ranged from 5.21 to 9.08%. Among the parents Tori-7 had the highest amount (8.97%) followed by (7.26%) in Brown Special while the lowest amount (5.96%) was estimated in Yellow Special. In the F_1 generations Yellow Special×Tori-7 had the highest amount (9.08%) which was higher than both of its parents followed by (7.31%) in BARI Sar-14×Tori-7 and the lowest amount (5.21%) was estimated in Brown Special×Yellow Special (Table 4). The arachidonic acids contents ranged from 0.51 to 1.01%. BARI Sar-14 had the highest values (1.01%) followed by (1.00%) in Yellow Special among the parents. In the F_1 generations the highest amount (0.94%) was estimated in Brown Special×Yellow Special which was higher than one of its parent and the lowest (0.51%) was estimated in Yellow Special×Tori-7 (Table 4). So, the parents and F_1s with the high level of linoleic, linolenic and arachidonic acids could be selected for further improvement of this trait. The result for linoleic acid was found to be lower than the findings of Karmokar (2020) and Islam et al. (2020a) who reported that it ranged from 12.53 to 14.27% and 12.70 to 17.75% in different rapeseed and mustard variety. Fadl et al. (2011), Amir et al. (2012) and Mubashir (2012) also found 12.37 to 21.36%, 15.87 to 19.06% and 15.00% linoleic acid respectively in rapeseed-mustard oil. This low level of linoleic acids might be due to increased amount of erucic acid in them. For linolenic acid the result remained within the findings of Amir et al. (2012), Mubashir (2012), Karmokar (2020) and Islam et al. (2020a) who reported 7.55 to 9.76%, 6.00%, 6.69 to 8.65%

Table 4: Major polyunsaturated fatty acid compositions of selected *Brassica rapa* and their F_1s genotypes

Genotypes		Polyunsaturated fatty acids (%)		
		Linoleic acid (C18:2)	Linolenic acid (C18:3)	Arachidonic acid (C20:4)
Parents	(P_1) BARI Sar-14	7.14^{f}	6.10^{g}	1.01^{a}
	(P_2) Brown special	7.58^{d}	7.26^{d}	0.75^{d}
	(P_3) Yellow special	8.16^{b}	5.96^{h}	1.00^{ab}
	(P_4) Tori-7	7.35^{e}	8.97^{b}	0.66^{e}
F_1s	BARI Sar-14×Brown special	6.70^{h}	6.97^{e}	0.79^{cd}
	BARI Sar-14×Yellow special	7.58^{d}	5.68^{i}	0.82^{c}
	BARI Sar-14×Tori-7	6.84^{g}	7.31^{c}	0.77^{cd}
	Brown special×Yellow special	7.84^{c}	5.21^{j}	0.94^{b}
	Brown special×Tori-7	7.35^{e}	6.64^{f}	0.82^{c}
	Yellow special×Tori-7	9.68^{a}	9.08^{a}	0.51^{f}
	Minimum	6.70	5.21	0.51
	Maximum	9.68	9.08	1.01
	Mean	7.62	6.92	0.81
	CV%	0.26	0.28	4.47
	LSD	0.03	0.03	0.06

Figure in a column followed by a common letter do not differ significantly at (p=0.05) level by DMRT

and 6.27 to 11.83% linolenic acids in different rapeseed-mustard oil respectively while for arachidonic acids Islam et al. (2020a) also reported less than 1.00% arachidonic acids in different rapeseed and mustard varieties.

4. CONCLUSION

All the F_1 genotypes contained lower amount of oils than their parents did, so, these should not select for improving this trait. As the F_1–Yellow Special×Tori-7 contained the highest amount of polyunsaturated fatty acids with a comparatively lower amount of undesirable erucic acid than their both parents. Therefore, it could select for further improvement of this trait. The F_1– Brown Special×Yellow Special contained a very high amount of erucic acid thus; it might use for commercial purposes.

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