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# Effect of Bioactive Compounds on Seed and Oil Content of Brassica Genotypes

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**ABSTRACT: Rapeseed and mustard belongs to the own circle of relatives particularly brassicaceae or cruciferae are an essential oilseed crop and presently ranked third because it is the world's most crucial oilseed crop in terms of production and area. Among the species, *Brassica napus* and *Brassica campestris* appears as rapeseed while *Brassica juncea* is considered under the category of Indian mustard. Rapeseed (*B. napus* subsp. napus) is a bright-yellow flowering family member of Brassicaceae (mustard or cabbage own circle of relatives), cultivated specifically for its oil-wealthy seed, which certainly incorporates considerable quantities of erucic acid. Rapeseed oil is one of the oldest recognised vegetable oils, however traditionally it is utilized in constrained portions due to the presence of excessive degrees of erucic acid. Consequently, erucic acid constraints of mustard seeds have been recognised for a longer period of time however, it has become deliberately no longer managed or overlooked. Therefore, in the recent years, research have been currently focussed on developing those genotypes which can be exploited in plant breeding programmes for improvement of nutritionally higher pleasant regionally adaptive cultivars. Since oil containing excessive quantity of erucic acid is undesirable for human consumption, therefore improvement of genotypes that are devoid of erucic acid content material and a few different biologically energetic compounds of their oil and glucosinolate in meal is breeding targets of this oilseed crop. In addition, breeding goals should also emphasize on the development and release of these low erucic acid genotypes by crossing two superior genotypes. Since humans consume various biologically active compounds including isothiocyanates, bisphenol F, erucic acid, or allergens that are naturally present in mustard seeds and its by-products, therefore based on the concerned problems, additional importance should be given on research including selection of suitable superior genotypes and techniques of reducing bioactive compounds particularly erucic acid in seed and oil as well as minimizing their harmful effects on metabolic function of human body have been particularly reviewed in this paper.**

**Keywords:** Rapeseed, Mustard, Erucic Acid, Linoleic Acid, Oil Quality, Bioactive compounds, Human consumption, Epideomological studies.

## INTRODUCTION

Rapeseed is an important oilseed crop that has been considered as an essential source of vegetable oil, as well as the second largest oilseed crop after soybean (FAO, 2007). Among the nine major oilseed crops widely grown in India, rapeseed and mustard occupies the second most important position after soybean because of its greater sustainability and adaptability to varied agro-ecological situations (Choudhary *et al.*, 2022). In India, mustard crop is broadly cultivated in *Rabi* season from September-October to February-March. Sandy loams to clay loam soils are considered suitable for cultivation but thrive best on light loamy soils. Soils having neutral pH are ideal for their proper growth and development (Meena *et al.*, 2022). The major reason for gaining popularity of rapeseed worldwide is largely because of the improvements in seed oil and meal quality. Seed oil and flour, derived from it is extremely appreciable due to the presence of low levels of saturated fatty acids approximately 7% and unsaturated fatty acids on which cholesterol-free oils from rapeseed and mustard have the best quality nutritional value among whole oilseeds (Thomas *et al.*, 2012). From a nutritional point of view, linoleic acid is considered the most essential unsaturated fatty acid and must be absorbed by the human body through food consumption because it cannot be synthesized naturally within the body.

The quality of oilseed oil, especially rapeseed, depends mainly on the presence of saturated and unsaturated fatty acid compounds, including linolenic acid, erucic acid and oleic acid as well as fatty acids medium chain in addition to varietal breeding and therefore the breeding goals must mainly focus on improving its quantity and quality (Divakaran *et al.,* 2016). Comparison of rapeseed mustard oil with other oilseed crops in terms of bioactive compounds have been presented in Table 1 (Kumar *et al.,* 2014). In terms of genotypes, highest percentage of erucic acid (50%) is present in Indian mustard (*B. juncea*). But for consumption purpose, erucic acid content of less than 2% is highly preferable. Indian mustard is commonly known as raya and cytologically it is an amphidiploid crop (2n=36) derived from natural chromosomal doubling of interspecific cross between *Brassica nigra* (2n=16) and *Brassica campestris* (2n=20) (Choudhary *et al.,* 2022). As per the results obtained by the researchers in terms of selection of suitable genotypes, it was observed that the new rapeseed cultivars consisted of more than 60% oleic acid and 10-20% linoleic acid while the percentage of linolenic acid had decreased (10%) (FAO, 2021). The main objective of oil quality modification is to produce oils with improved nutritional and functional properties.

According to Mollers in 2004, several genotypes of rapeseed with fatty acid composition (Fig. 2) are available for different purposes (Table 2) (Rai *et al.,* 2018).

**Table 1: Comparison of rapeseed mustard oil with other oilseed crops in terms of bioactive compounds (Source: Kumar *et al.,* 2014).**

| Oilseed crops | Oil content | Protein content | Palmitic+Stearic acid | Oleic acid | Linoleic acid | Linolenic acid | Arachidic acid | Erucic acid | References |
|---|---|---|---|---|---|---|---|---|---|
| Rapeseed Mustard | 34.9-44.9 | 17.8-22 | 4.4 | 13.3 | 18.4 | 15.7 | - | 41.4 | Chauhan *et al.* (2011) |
| Soyabean | 8.1-27.9 | 34.1-56.8 | 14 | 18 | 55 | 13 | - | - | Clemente and Cahoon (2009) |
| Groundnut | 33.60-54.95 | 18.92-30.53 | 10.69 | 58.69 | 21.76 | 0.34 | 1.83 | - | Aluyor *et al.* (2009) |
| Sunflower | 19.8-26.7 | 10-25 | 10.9 | 31.5 | 52.8 | 0.4 | 0.4 | - | Rafalowski *et al.* (2008) |

**Table 2: Composition of fatty acid in several genotypes of Brassica (Source: Rai *et al.,* 2018).**

| Saturated Fatty acid (%) | | | | Unsaturated Fatty acids (%) | | | |
|---|---|---|---|---|---|---|---|
| **Sr. No.** | **Varieties (*Brassica juncea* genotypes)** | **Palmitic acid** | **Oleic acid** | **Linoleic acid** | **Linolenic acid** | **Eicosenic acid** | **Erucic acid** |
| 1. | RSPR-03 | 3.44 | 10.35 | 20.77 | 24.08 | 1.11 | 40.21 |
| 2. | Kranti | 3.85 | 7.34 | 18.57 | 24.40 | 0.00 | 45.83 |
| 3. | Pusa Bold | 3.68 | 7.10 | 16.41 | 22.32 | 1.05 | 49.40 |
| 4. | Varuna | 3.23 | 10.92 | 18.50 | 20.94 | 1.26 | 45.13 |
| 5. | RSPR-01 | 3.59 | 8.24 | 18.17 | 26.72 | 0.00 | 43.24 |
| 6. | RL 1359 | 3.47 | 8.67 | 17.41 | 24.03 | 0.00 | 46.39 |
| 7. | Pusa Mahak | 3.08 | 7.60 | 15.33 | 24.44 | 1.04 | 48.48 |
| 8. | NPJ-153 | 3.30 | 8.19 | 18.34 | 23.06 | 0.00 | 47.09 |
| 9. | PM-21 | - | 0.90 | 39.80 | 13.60 | 29.50 | 0.90 |
| 10. | PM-22 | - | 1.00 | 45.30 | 11.10 | 34.50 | 1.00 |
| 11. | PM-24 | - | 0.80 | 34.20 | 15.20 | 34.90 | 0.80 |
| 12. | Pusa Karishma | - | 0.90 | 37.60 | 18.80 | 31.30 | 0.90 |
| 13. | Nov Gold | - | 48.70 | 11.00 | 17.80 | 14.80 | 48.70 |
| 14. | NRCDR-2 | | 47.40 | 11.50 | 12.00 | 15.50 | 47.40 |
| | Mean | | 12.01 | 23.06 | 19.89 | 11.70 | 33.25 |
| | Range | 3.08-3.85 | 0.80-48.70 | 11.00-45.30 | 11.10-26.72 | 0.00-34.90 | 0.80-49.40 |
| | ***Brassica napus* genotypes** | | | | | | |
| 1. | RSPN-28 | 4.87 | 19.45 | 21.67 | 11.20 | 14.72 | 28.05 |
| 2. | RSPN-29 | 4.14 | 24.13 | 20.71 | 11.24 | 15.94 | 23.80 |
| 3. | DGS-1 | 4.32 | 16.15 | 18.57 | 9.99 | 15.97 | 34.96 |
| 4. | GSL-1 | 4.71 | 21.06 | 18.83 | 10.58 | 13.64 | 31.15 |
| 5. | RSPN-25 | 5.15 | 20.76 | 19.87 | 10.30 | 15.58 | 28.29 |
| 6. | HNS0901 | 4.36 | 34.68 | 23.01 | 14.31 | 12.58 | 10.04 |
| 7. | GSL 101 | 3.70 | 37.98 | 26.93 | 17.23 | 0.00 | 15.01 |
| | Mean | 4.46 | 24.89 | 21.37 | 12.12 | 12.63 | 24.47 |
| | Range | 3.70- 5.15 | 16.15-37.98 | 18.57-26.93 | 9.99-17.23 | 0.00-15.97 | 10.04-34.96 |
| | ***Brassica rapa* genotypes** | | | | | | |
| 1 | RSPT 01 | 2.75 | 12.67 | 16.82 | 9.97 | 10.13 | 47.63 |
| 2 | RSPT 02 | 2.99 | 10.17 | 15.18 | 10.75 | 10.87 | 49.99 |
| 3 | RMT 08-02 | 3.73 | 11.73 | 18.18 | 20.89 | 1.67 | 43.77 |
| 4 | PT 303 | 3.00 | 16.15 | 16.06 | 9.82 | 10.85 | 44.10 |
| 5 | RH 0701 | 3.11 | 6.21 | 14.08 | 26.66 | 5.13 | 44.79 |
| | Mean | 3.12 | 11.39 | 16.06 | 15.62 | 7.73 | 46.06 |
| | Range | 2.75-3.73 | 6.21-16.15 | 14.08-18.18 | 9.82-26.66 | 1.67-10.87 | 43.77-49.99 |

Mustard oil can be used in two different forms; as a fatty vegetable oil and an essential oil from pressing and grinding of the seeds as well as from extraction of volatile oil by distillation. Quality is a relative term and should be defined in the context of the scope, e.g.,: a variety is high in oleic acid, but the same variety may be deficient in linolenic acid. The nutritional quality of rapeseed and mustard seeds is determined by several factors such as oil content and its fatty acid constituents, protein content, amino acid concentration, crude fibre and various anti-nutritional factors including glucosinolates, phytic acid and synaptin. It is also determined by the content of fatty acids, oleic acid, linoleic acid and erucic acid. Mustard oil is not considered safe for human consumption in the United States, Canada and the European Union due to its high erucic acid content thereby leading to toxicity, while in India, it is mustard oil that is usually heated first to be used for cooking, which helps in reducing the content of harmful substances without any reduction in strong smell and taste. As per the study conducted by several researchers, oil content of Brassica species ranged from 40% to 46.7% (Kumar *et al.,* 1980).

In rapeseed and mustard, there is a presence of saturated fatty acids with single bonds and unsaturated fatty acids with double and triple bonds. Edible oils composed of a higher concentration of saturated fatty acids are considered harmful for human health. As per the reports of EFSA, 2016 and Ackman *et al.* (1977), it has come to a conclusion that due to its high intake of erucic acid in the diet, it causes decreased myocardial conductance, myocardial fibrosis, lipidosis and increased blood cholesterol. Its anti-nutritional property is mainly attributed to its metabolic inertia, since it does not allow entering the stage of beta-oxidation to produce ATP (Rogers, 1978). In the recent years, people get conscious about their healthy diet upon consumption of food and primarily focus on essential fatty acids, blood lipid management, maintenance of endocrine and immune function, inflammation control, metabolic effects etc (Bhoge, 2015). Thus, oils containing less than 2% acid erucic acids are considered suitable for consumption. Consequently, palmitoleic acid is an important intermediate component in the synthesis of long chain (n-7) fatty acids as reported by Bhogal *et al.* (2014).

According to the research conducted by Przybylski and Mag in 2002, there has been an enormous growth in rapeseed production over the past forty years due to its low erucic acid (docosenoic acid 22:1: cis-13) and glucosinolates content. In India, the restriction on excessive use of mustard oil is in view and foreign multinationals have attempted to replace mustard oil with canola oil, which is also regarded as low erucic acid variety of canola. People in northern India have used it for centuries and disagreed about the enough evidence of erucic acid toxicity and have put into confliction that mustard oil is beneficial for human health due to its lower concentration of saturated fatty acids, ideal ratio between omega 3 and omega 6 fatty acids (15 g of omega 3 fatty acids per 100 g serving), antioxidants and vitamin E, as well as it is cold pressed (extracted at 45-50 degrees Celsius). For obtaining good quality oil as well as for imparting longer shelf life, rapeseed mustard oil consisting of high oleic and low linolenic acid is considered to be superior. Edible oil also should have higher ratio of oleic to linoleic fatty acid and linoleic (ω-6) to linolenic (ω-3) fatty acid (Kumar and Bala, 2013). Since oil containing higher amount of erucic acid is undesirable for human consumption, therefore development of commercial varieties free from erucic acid content in their oil and glucosinolate in meal is breeding objectives in this oilseed crop.

Recommendation for use of rapeseed and mustard oil in addition to seed meal for consumption purpose is comparatively different from that of industrial requirements in terms of presence of lower concentration of saturated fat, higher content of oleic acid, balanced ratio of saturated fatty acid/monounsaturated fatty acid/polyunsaturated fatty acid and antioxidants and absence of trans-fat and minimum anti-nutritional factors. On the other hand, some of the anti-nutritional factors are known to be in relation with some plant defence system and other important biological functions. Due to these factors, the investigation on crop quality research have brought to a higher level with an objective of producing particular crops specific for consumption and industrial purpose.

**Evolution of Erucic Acid in Rapeseed.** The amphidiploid species, *B. napus* (2n=38) containing erucic acid had been developed by using genes (Siebel and Pauls, 1989). Confirmation of 22:1 digenic inheritance in *B. juncea* as suggested by Kirk and Hurlstone in the year 1983 had turned into *B. carinata*. The 22:1 content material of oilseed rape (*B. napus*) is managed by using one-, one- or - and -loci alleles thereby resulting in 5-10%, 10-35%, and more than 35 percent 22:1, respectively. These results are in confirmity with the results of several researchers including Jonsson (1977) and Pourdad and Sachan (2003). The erucic acid content in rapeseed population containing two loci particularly controlled by the alleles is determined by using random fragment length polymorphism (RFLP) and random amplified polymorphic DNA (RAPD) markers respectively (Stefansson 1983; Jourdren *et al.,* 1996). Similarly, Thormann *et al.,* (1996) studied and concluded that venture of the 2 loci to unbiased linkage companies had turned into a quantitative trait locus (QTL). However, loci do now no longer make a contribution similar to erucic acid content. Various alleles appear at every locus and at least 5 alleles govern erucic acid in Brassica, including; Ea, Eb, Ec and Ed (Anand *et al.,* 1981). Therefore, erucic acid ranges may be set at a huge range of values starting from more than 1% to much less than 60% (Jonsson, 1977).

**Chemical Structure of Erucic acid.** Erucic acid is a mono-unsaturated fatty acid designated by its chemical formula $CH_3$ $(CH_2)$ 7CH=CH $(CH_2)_{11}COOH$. It is abundantly available in the seeds of wallflower as reported by Sahasrabudhe (1977) and contains about

20-54% high erucic acid in rapeseed oil and 42% erucic acid in mustard oil. It is also known as cis-13 docosenoic acid and its trans-isomer is known as brassidic acid. It is a natural unbranched fatty acid, composed of 22 carbon atoms and a double bond in cis configuration on $C_{13}$, chemically known as cis-13 docosenoic acid (Russo *et al.,* 2021) as shown in Fig. 1. Based on the results concluded by Abbott *et al.* (2003), it could be clearly indicated that foods that are rich in erucic acid, after consumption by humans, have a pessimistic impact on health since erucic acid is classified as a natural toxicant. Due to accumulation of triacyl glycerol, it causes harmful effects on heart because of insufficient oxidation as reported by Bremer *et al.* (1982). It might also lead to reduced contractility in heart muscle due to myocardial lipidosis according to recent reports (Knutsen *et al.,* 2017). They had also reported harmful effects of cardiac damage caused by insufficient metabolic degradation involving a reversible process by avoiding erucic acid consumption. According to the European Union Council Directive Reports in 1976 and Technical Report Series in 2003, highest levels of erucic acid had been developed in Western countries since 1970.

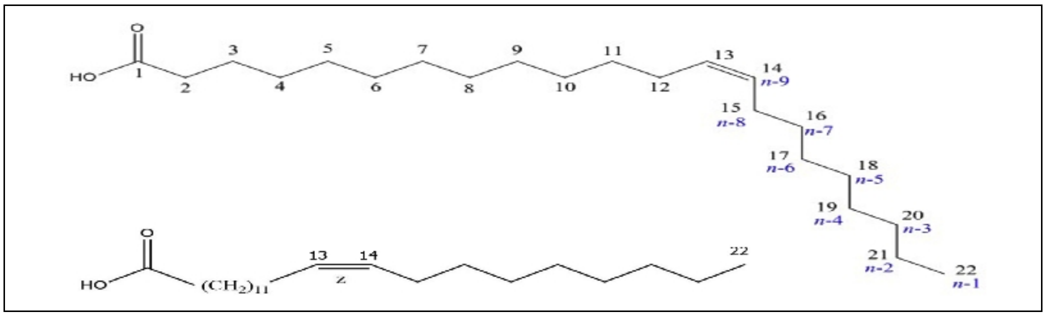

**Fig. 1**. Pictorial depiction of chemical structure of erucic acid indicating its carbon labelling.

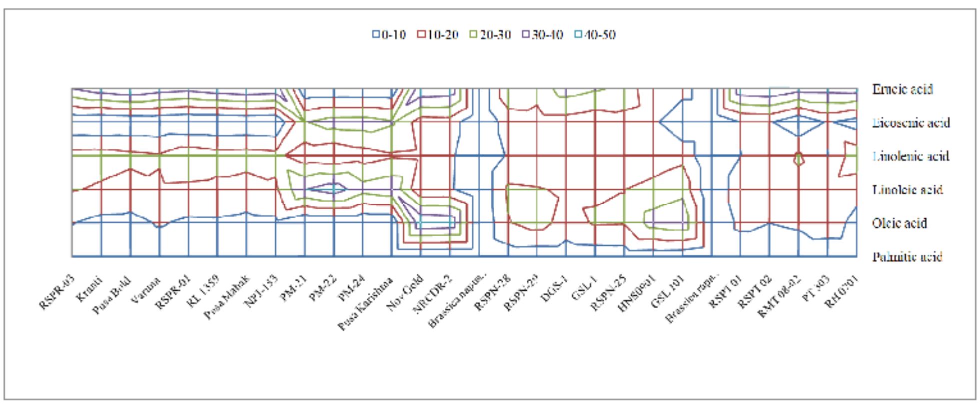


**Fig. 2.** Graphical representation on variations in composition of fatty acid content (%) in *Brassica juncea, Brassica napus and Brassica rapa* genotypes.

The European Union had introduced a maximum level of 5% contribution of erucic acid to total fatty acids in edible oils and added fats in 1976 (EU Council Directive 1976). Even stricter limit values had been set in Australia and New Zealand keeping in view of intake of maximum levels of erucic acid (2%) in oils as well as tolerable daily intake (TDI) of 7.5 mg/kg of body weight of erucic acid. (Technical Studies Reports Series, 2003). The primary objective of these laws is to differentiate traditional breeds of rapeseed containing more than 50% of total fatty acids commonly referred to as high erucic acid (HEAR) canola from newer breeds of rapeseed known as low erucic acid canola. (LEAR). Example: Canola oil. Efforts to reduce erucic acid content in rapeseed by the Canadian began in 1959 and according to the results observed by Eskin in 2003, it was concluded that the first successful LEAR cultivars were obtained in 1968. According to CODEXSTAN 210–1999, lower concentration of erucic acid in rapeseed genotypes contains a maximum of 2% erucic acid. The low rape seed oil is valuable edible oil due to its beneficial composition of fatty acid in combination with low omega-6 and high omega-3 thus producing a favorable report N6 / N3 of ~ 2 (Eskin, 2003). Wendlinger *et al.,* (2014) conducted research on mustard oils and reported that oil samples containing 5% erucic acid, was considered well above the European Union limit. Rastogi *et al.,* (2004) had confirmed that mustard oil in Europe is rarely used as edible oil compared to Asia and northern India and presence of high erucic acid in mustard oils is unexpected (Abul Fadl *et al.,* 2011). Wendlinger *et al.,*

(2014) stated that two 20 g servings of table mustard could exceed Australian TDI of erucic acid, in terms of juveniles due to lower body weight than adults. Oram *et al.,* (2005) conducted research and concluded that mustard seeds containing 45% erucic acid were recommended for cooking and storing, while 23% erucic acid was specifically recommended for table mustard. Among mustard varieties, brown mustard varieties (*B. juncea*) had the lowest erucic acid content, while white and black mustard varieties had uniformly high levels of erucic acid (Eskin *et al.,* 2003). Although erucic acid problems have been well known for some time, but the problem is still not been controlled at all and these relationships are consistent with the studies conducted by the researchers including Oram *et al.,* (2005), indicating Indian experts have highlighted this problem by stating health implications associated with erucic acid consumption and was not been observed in the Indian population. It had also been indicated that high α-linolenic acid content may compensate for the erucic acid content (Rastogi *et al.,* 2004). Erucic acid can be produced by the elongation of two coenzymes particularly oleoyl coenzyme A and malonyl coenzyme A. In addition, erucic acid has the potentiality in breaking down long chain to short chain fatty acids known as acyl coenzyme dehydrogenase enzyme present in human liver. In April 2010, the US Department had reported that a maximum of 2% erucic acid was regulated in rapeseed canola oil, canola oil, low erucic acid canola oil, and rapeseed oil, equivalent of canola oil and were also in accordance with the regulations conducted by the Commission of European Communities in 1980, indicating a maximum of 5% erucic acid was regulated for baby foods. Canola is derived from a cross between low erucic acid (*B. napus* and *B. rapa*) rapeseed cultivars specifically developed by Stefansson in the year 1983 at the University of Manitoba, Canada. The word "Canola" has been derived from "can" in "Canada" and "ola", meaning "oil with low acidity".

**Sources of Erucic Acid.** The name 'erucic acid' had been derived from the word "erca" which is a kind of flowering plants of the Brassicaceae family. The genus includes *Eruca sativa*, commonly known as rocket is a native to the United States or rocket from the United Kingdom. The erucic acid production process is a natural process with certain other fatty acids through green plants that belong to the members of the genus Brassica. Erucic acid can be used in different ways, for example for industrial purposes, food purposes containing low erucic acid canola commonly known as LEAR developed in rapeseed and specifically composed of fats derived from oleic acid instead of erucic acid (Anneken *et al.,* 2006). Major emphasis on varietal development should be associated with various quality parameters including different grades of oil comprising less than 7% saturated fat, 70% oleic acid, 40-50% linoleic (high linoleic ) and erucic acid '0' (less than 2%) meant for consumer purposes, industrial purposes, including high grade stearic acid of 20-40% for margarines, very low grade linolenic acid particularly less than 3% for extended shelf life and margarine and high erucic acid (40-50%) for polymers, lubricants and industrial plastics industries and more than 50% erucic acid for cosmetics and pharmaceuticals.

**Proportions of Erucic Acid in Mustard Cultivars.** Based on the study conducted in terms of selection of trait specific genotypes, Golam *et al.,* (2006) had stated that the variety Barisarisha 8 from *B. napus* had considerably ($P < 0.001$) low ranges of erucic acid and excessive ranges of oleic, linoleic, and linolenic acids. The erucic acid content (22:1) varies broadly from 21.9% to 51.57%. While on the alternative hand, varieties including Binasarisha-3, Binasarisha-4, Binasarisha-5, MM 221298, MM 21698, MM 36698, MM 49398, MM 34798 and Barisarisha-8 had a considerably low level (P = e 0.001) of erucic acid (21.9%–36.32%). These results are opposite to what had been stated by several researchers including Abdellatif and Vles (1971). As consistent with the reviews stated so far by Kaul *et al.,* (1986) it could be concluded that the cultivars particularly Tori-7, Safal, Agrani and Rai-5 incorporate 46.70–51.90% erucic acid, while Barisarisha-8 contained the bottom quantity of erucic acid (36.4%). It had been found significantly similar with the results of Koyama in 1978 that huge part of oleic acid had transformed to erucic acid in rapeseed and mustard seed oils. Similar effects had been found in cauliflower by Ahuja in the year 1987 and Agarwal *et al.,* (2003) in Indian mustard (*B. juncea*).

**Toxicological and Anti-nutritional Effects of Biologically Active Compounds on Mustard seeds.** In addition to imparting flavour to foods, humans consume several biologically active compounds including isothiocyanates, bisphenol F, erucic acid, or allergens found in mustard seeds and its by-products, thereby possessing harmful effects on human health. It is due to the fact that it contains several toxicological or undesirable bioactive compounds particularly responsible for causing health problems. Bioactive compounds, especially long-chain fatty acids (erucic acid) appearing in esterified or serum albumin form, are gradually transported into human cells and tissues and eventually gets synthesized into lipoproteins.

This long-chain fatty acid predominently acts as compounds for building energy in the heart and skeletal muscle and undergoes the process of mitochondrial beta oxidation. However, oxidation potential of mitochondrial beta-oxidation in erucic acid is reduced to less than 18 carbon atoms. It is mainly due to less utilization of urocyl coenzyme A by mitochondrial acyl coenzyme A dehydrogenase; For example, when an erucic acid is activated directly as a substrate through human heart for energy acquisition, level of mitochondria in the human heart decreases (Clouet *et al.,* 1979). Higher consumption of fatty acids, particularly erucic acid, reduces the process of activation of acyl groups of coenzyme A into carnitine that acts as a preliminary phase of beta-oxidation (Clouet *et al.,* 1979). Another example of epidemiological studies that are based on adverse effects of consumption of higher levels of biologically active compounds including docosenic acid (22:1) and nerve acid (24:1) in plasma phospholipids leads to the developmental congestive heart failure which aids in the formation of cardiac toxicity in human heart (Imamura *et al.,* 2013). Based on the survey conducted by the EFSA Panel on Contaminants in the Food Chain (CONTAM), it was significantly analysed that consumption of oilseeds containing a higher concentration of erucic acid is considered toxic because it is strongly associated with the incidence of lipidosis in humans, particularly responsible for cardiac toxicity (EFSA, 2016).

In addition, it is also responsible for myocardial fibrosis and increase in the level of blood cholesterol. Its anti-nutritional property does not allow entering into the beta-oxidation pathway in order to produce ATP (Rogers, 1978). Therefore, consumption of oilseeds containing high erucic acid content has been restricted by several regulatory agencies. Another international regulatory agency namely "The Australia New Zealand Food Standards Code (FSANZ) has deemed that consumption of more than 2% erucic acid in the form of edible oils is considered undesirable for humans (FSANZ, 2016). Similar regulations had been applied by the European Union and due to this reason these agencies have fixed some policies and regulations not to exceed more than 2% erucic acid content in mustard oil for consumption purpose.

**Nutritional benefits of Mustard seeds.** Based on the study of significance of mustard seeds particularly white or unheroic mustard (*Sinapsis alba*) and brown mustard (*Brassica juncea*) from nutritive and functional perspective, it can be estimated that food and the beverage industries at the current situation is extensively arising. Moreover, presence of bioactive compounds similar to isothiocyanates in mustard seeds act as an implicit source of nutrition and is also responsible for imparting flavour in foods. Hence, in the recent times, graph indicating foods and beverage industries are in an increasing trend.

**Methods of Reduction of Erucic Acid Content in Oilseed Crops.** Production and activation of long-chain fatty acids (erucic acid) in mustard seeds primarily depends on several biotic and abiotic factors particularly cultivation techniques, varietal selection, total oil content, pedoclimatic conditions as well as morphological and physiological factors (Mandal, 2002). Therefore, breeding goals should be emphasized entirely on the development and release of these low erucic acid genotypes by crossing two superior genotypes (Burton, 2003). Another aspect of reducing erucic acid content in edible oil is the natural production of alpha-linolenic acid in mustard seeds which ultimately helps in balancing the ratio of erucic acid content (Rastogi *et al.,* 2004).

**Global Quality Standards.** Based on the legislation conducted by the World Health Organization / Food and Agriculture Organization, it has been confirmed that the percentage of saturated fatty acids must be less than 7% indicating a sum of C16: 0 + C 18: 0 + C 20: 0 + C 22: 0 etc. On the other hand, percentage of oleic acid content must be high (C18:1). In terms of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids, ratio should be within the range of 1:13:1, while the PUFA: SFA ratio should be within the range 0.8-1.0. Consequently, in terms of linoleic acid and linolenic acid content, it should be in the 5-10 range. However, presence of antioxidants, including tocopherols, in mustard oil further helps in oxidation process. Therefore, consumption of oil and seed meal containing erucic acid lower than 2% and glucosinolates less than 30μmole/g have been proven to be beneficial and nontoxic to human health (Thacker, 1990).

## CONCLUSION

Based on the study of nutritive values and its functional properties of rapeseed and mustard seed, it can be concluded that the utilization of mustard seeds and its value-added products would increase enormously in the future considering its biologically active compounds assets. Additionally, breeders have developed those Brassica genotypes that are low in erucic acid content and other biologically active compounds and have given much priority on research that are based on reduction of other bioactive compounds including unsaturated fatty acids and medium chain fatty acids in addition to reducing health problems with accumulation of 2% erucic acid in mustard seeds and oil. Reviews contained in this manuscript are mainly focused on the concept of accumulation of appropriate content of erucic acid with respect to concentration of saturated fat, trans fat, ratio of linoleic (ω6) and linolenic (ω3) acids, saturated fatty acids (SFA) / fatty acids mono unsaturated fatty acids (MUFA) / polyunsaturated fatty acids (PUFA) ratio, concentration of anti-nutritional factors including erucic acid, glucosinolates, phytic acid, synaptic acid and tannins etc., presence of various phenolic compounds that are responsible for functioning as an antioxidants and taste determinants, decrease in the fibre content of seed meals, association of glucosinolates with different biotic and abiotic stress and other biological activities, including anticancer activities, due to the presence of isothiocyanates.

## FUTURE SCOPE

Based on the selection of genotypes possessing desirable characteristics in terms of presence of optimum concentrations of bioactive compounds particularly linolenic acid ranging from 3.5% to 20%, medium and high percentage of oleic acid (65-75%), and balanced ratios of saturated fatty acids, monounsaturated fatty acids, poly unsaturated fatty acids in addition to Omega 6 and Omega 3 etc; screening of rapeseed and mustard germplasm is highly essential in order to identify trait specific germplasm suitable for human consumption as well as for further utilization and conservation by adoption of breeding and crop improvement programme. Moreover, selection of genotypes should also be confined to suitability on human body metabolism since they consume several biologically active compounds including isothiocyanates, bisphenol F, erucic acid, or allergens that are naturally present in mustard seeds and its by-products, thereby creating a detrimental effect on human metabolism and ultimately leading to deterioration in health.

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