

Oil-quality enhancement of rapeseed mustard

significance, achievements and future challenges

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Rapeseed mustard is the most important source of edible oil in India next to soybean. Amount and proportion of different fatty acid in edible oil determines its suitability for consumption. Erucic acid in oil and glucosinolates in de-oiled cake are two nutritionally undesirable factors in rapeseed mustard. Indian scientists have bred mustard varieties having erucic acid < 2% in oil and glucosinolates < 30 μ moles/g in defatted seed meal, which is an internationally acceptable or 'Canola' (00) standard. To meet the increasing demand of quality edible oil and to reduce the expenditure on import of Canola oil, a lot of innovations spanning over research, extension and policy framework are needed for development and popularization of these varieties.

Key words: Canola, Erucic acid, Glucosinolates, Mustard, Rapeseed

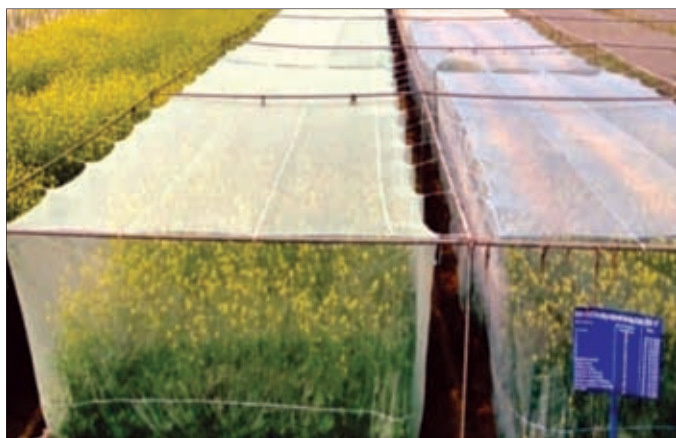


Fig. 1. Maintenance of breeding material low in erucic acid or glucosinolates



Fig. 2. PDZM-31: A canola quality variety of Indian mustard at IARI farm, New Delhi

OIL quality is a complex character determined by several inter-reliant indices such as nutritional and cooking parameters, consumer preference, palatability, industrial suitability, physical appearance, market acceptability, shelf-life etc. Fatty acid profile, proteins and essential amino acids determines the nutritional quality of oil and seed meal. Improper dietary intake of fat and lack of physical workout are closely associated with life-styles diseases which are becoming more common and preventative in modern life. As per WHO, during 2015 an

estimated 17.7 million people died globally from cardiac ailments such as myocardial infarction (heart attack), stroke, and peripheral vascular diseases, representing 31% of all the deaths. Of these deaths, an estimated 7.4 million were due to coronary heart disease and 6.7 million were due to stroke. The quality and quantity of dietary fat and oil largely affect functioning of heart. Cholesterol, saturated and trans-fats are closely related to coronary artery disease (CAD). Life-style changes to include physical workout have to be brought about by an individual. Plant breeders

have been attempting to increase the nutritional quality of the oil by eliminating the undesirable traits so as to minimize the risk to the heart.

Cholesterol: bad versus good

Cholesterol is an integral component of cell membrane and is essentially required for proper functioning of brain and body; it acts as a precursor for biosynthesis of vitamin-D, adrenal and sex hormones. All animal-based foods (egg, red meat, poultry and sea foods), and fats (butter, ghee etc.) contain cholesterol in varying



Fig. 3. Seeds of rapeseed mustard after treatment of PDZM 310

amounts. However, fats of plant origin i.e. vegetable oils are free from cholesterol, though some of them can lead to the endogenous production of cholesterol. Broadly, cholesterol can be classified in two types:

- (i) Low density lipoprotein or 'Bad Cholesterol': It causes fat plaque formation in arteries resulting in coronary artery disease.
- (ii) High density lipoprotein or 'Good Cholesterol': It acts as balancing force by removing bad cholesterol from the arteries.

Trans fats

'Trans' fats are stereo isomers of 'cis' unsaturated fatty acid i.e. it has different spatial arrangement of atoms around carbon-carbon double bond as opposed to 'cis' isomer. The difference between 'cis' and 'trans' is that the two H atoms are on the same side of the double bond (cis), compared to being on opposite sides (trans).

Partial hydrogenation and deep frying of vegetable oil yield 'trans' fats, which elevate the risk of coronary artery disease. From health perspective, it is the worst kind of fat as it increases the level of Low density lipoprotein (LDL) and decreases the level of High density lipoprotein (HDL) good cholesterol. Snacks, margarine, packaged baked food (biscuits) and fried fast food are the major sources of 'trans' fats.

Saturated and unsaturated fat

As a common feature, majority of vegetable oils are odourless and tasteless but greater variability lies in their fatty acid composition. Based on the presence of carbon-carbon

double bond in molecular structure, fats are of two kinds:

- (i) *Saturated fat* (ghee, butter, coconut oil): these fats lack double bond in carbon chain and remain solid at room temperature. Its consumption increases the amount of low density lipoprotein in body leading to coronary artery disease.
- (ii) *Unsaturated fat*: it possesses one or more carbon-carbon double bonds in the fatty acid chain. Further, depending on the number of double bonds in carbon chain, unsaturated fat is of two types:
 - (a) Monounsaturated fatty acid (MUFA) e.g. oleic acid (Omega-9 MUFA): it has got a single carbon-carbon double bond. Olive oil, mustard oil and groundnut oil are good sources of MUFA.
 - (b) Polyunsaturated fatty acid (PUFA) e.g. linoleic acid (Omega-6 PUFA) and alpha linolenic acid (Omega-3 PUFA): it possesses two or more carbon-carbon double bonds. Safflower, sunflower and soybean oil are chief sources of PUFA.

A diet rich in MUFA offers dual benefit as it helps to lower bad LDL cholesterol and elevate the good HDL cholesterol. Besides this, high oleic acid content (MUFA) helps in increasing the shelf-life of oil. Consuming the long-chain and omega-6 fatty acids can improve blood triglycerides and HDL. It decreases LDL and total cholesterol by 8% to 12% when compared to saturated fatty acids. Linoleic acid, omega-6 PUFA is an essential fatty acid which is the basis for production of prostaglandins and other essential body regulators. Linolenic acid, omega-3, although polyunsaturated and an essential dietary fatty acid, is undesirable in edible oil because of its three double bond structure which makes it prone to auto-oxidation, resulting in off-flavors and reduced

shelf-life of the oil. Hydrogenation of linolenic acid is not considered economical as it gives rise to biologically inactive isomers.

Omega-6 PUFA is pro-inflammatory, whereas, omega 3 PUFA are anti-inflammatory; therefore, the balance in dietary intake of pro-inflammatory to anti-inflammatory fatty acids is vital for a healthy life. Humans are thought to have evolved with a diet of a 1 to 1 ratio of Omega-6 to Omega-3. However, scientists suggested optimal ratio for reducing the risk of cardiac disease to be varying from 4: 1 to 1: 1.

Smoke point

Thermo-stability of oils is equally important and characterized by the smoke point, which is the temperature when cooked oil begins to emit bluish smoke. Oil with high smoke point can withstand deep frying without formation of 'trans' fats and has good oxidative stability. The smoke point indicates the beginning of nutritional degradation of oil besides imparting an off flavour to the cooked food. Smoke point of mustard oil is 250°C. Oils with high smoke point are especially suitable for deep frying.

Refined versus unrefined oil

To obtain refined oils, crushed seed are subjected to extraction process involving use of heat and chemical solvent (mostly hexane). The extracted oil then undergoes refining through degumming, neutralization and bleaching. High temperature and refining process causes formation of free radicals and degradation of vitamin E. On the other hand unrefined oils are obtained by pressing the seeds with heat (expeller pressed) or without heat (cold pressed /*kacchi ghani*). Health-wise, unrefined oils are superior due to presence of antioxidants, flavors and vitamin E content.

Rapeseed mustard: a major oilseed crop of India

Rapeseed mustard is the third most important source of vegetable oil in the world after soybean and palm oil and second most consumed

Table 1. Fatty acid composition of some important fat sources

Fats/Oils	Saturated fatty acid (SFA)	Oleic acid (Omega-9 MUFA)	Linoleic acid (Omega-6 PUFA)	α -Linolenic acid (Omega-3 PUFA)	Erucic acid	N-6/N-3 ratio (ideal 1:1 to 1:4)
Conventional mustard	7	25	12	10	45-55	1.2:1
Single zero	7	Up to 50	15	13	<2	1.2:1
Canola	4	62	22	10	<2	2.2:1
Ghee	65	32	2	<1	-	3:1
Soybean	15	27	53	5	-	10.6:1
Red palm	50	40	9	<0.5	-	18:1
Olive oil	13	76	10	<0.5	-	20:1
Palm oil	45	44	10	<0.5	-	20:1
Rice bran	22	41	35	1.5	-	23:1
Groundnut	24	50	25	<0.5	-	50:1
Sunflower	13	27	60	<0.5	-	120:1
Safflower	13	17	70	<0.5	-	140:1

Source: POS, Pilot Plant Corporation; Saskatoon, Saskatchewan; Canada, June 1994; National Institute of Nutrition, India, 1995

edible oil in India. India has a 40% share in the total rapeseed-mustard production in Asia. In our own country, rapeseed mustard has about 24% share in total oilseed production ranking second after soybean. Rapeseed mustard belongs to the genus *Brassica* comprising of various species (*Brassica juncea*, *Brassica rapa*, *Brassica napus* and *Brassica carinata*) which are the source of edible oil. In India, more than 85% of the total area under rapeseed mustard is occupied by the Indian mustard *Brassica juncea*. Due to diverse agro-ecological niche and varied consumer preference, whole array of fat sources are popular in Indian cuisines. A brief comparison of various fats/oils is mentioned in Table 1.

Erucic acid and Glucosinolates

Table 1 indicates that a great variability exists in the fatty acid profile of various vegetable oils, therefore, none of the oil is perfect and complete for human health yet it is evident that mustard oil can be considered nearly perfect edible oil. Mustard oil extracted from *Brassica juncea*, commonly called Indian mustard, is better than even Canola oil extracted from *B.napus*, in terms of low Omega-6 PUFA and nearly perfect N6 (linoleic acid) to N3 ratio (α -linolenic acid) ie: 1:1. Erucic acid, a 22-carbon mono-unsaturated fatty acid, is predominant in Indian mustard cultivars and is 45 to 55% of total fatty acid. However, the presence of high erucic acid in mustard oil is

considered anti-nutritional, as it elucidated to cause lipidoses and myocardial fibrosis in children and laboratory animals. High erucic acid in rapeseed oil is not metabolized and is reported to impair peripheral vascular system, decrease coagulation time and to increase blood cholesterol.

As discussed earlier, defatted mustard seed meal is an excellent source of animal nutrition as it

contains about 40% high quality protein owing to the balanced amino acid composition. However, its use as animal feed especially for pigs and poultry is restricted due to high content of sulphur-rich glucosinolates which yield toxic and goitrogenic cleavage products besides reduced palatability due to pungency of the meal. High Glucosinolate content leads to the alterations of the size, structure and function of the thyroid and damages liver and kidneys.

Single Zero ('0') and Double Zero ('00') 'Canola quality varieties' of Indian mustard

Erucic acid in oil and glucosinolates in de-oiled cake are two nutritionally toxic undesirable factors in rapeseed-mustard. Varieties having oil with < 2% erucic acid and glucosinolates < 30 μ moles/g defatted seed meal are termed as 'Canola' (00) quality and fetch premium in the International market. Indian cultivars possess high glucosinolates (100-280/moles/g defatted seed meal). The Indian mustard varieties fulfilling the

Table 2. Characteristic features of quality varieties released from IARI, New Delhi

Variety of Rapeseed-Mustard	Release year	Avg. yield (q/ha)	Oil content (%)	Maturity (days)	1,000 seed weight (g)	Recommended for
Pusa Karishma	2005	22.0	38	148	3.37	NCR, Delhi
PM-21	2007	21.1	35.6	142	4.3	NWPZ or Zone II comprising of Rajasthan, Punjab, Haryana, Plains of Jammu & Kashmir, Delhi and Western Uttar Pradesh.
PM-21	2008	18.60	35.6	133	4.3	Central Zone or Zone III (Uttar Pradesh, Uttarakhand, Chhattisgarh and Madhya Pradesh).
PM-24	2008	20.2	36.55	140	4.0	Delhi, Rajasthan, Punjab, Haryana, Plains of J&K and Western Uttar Pradesh.
PM-22	2008	20.7	36.0	142	3.6	NCR, Delhi.
PM-29	2013	21.7	37.2	143	3.93	Delhi, Haryana, Jammu. Punjab and north Rajasthan.
PM-30	2013	18.2	37.7	137	5.38	Uttar Pradesh, Uttarakhand, Madhya Pradesh and eastern Rajasthan.
PDZM-31*	2015	23.8	40.6	144	3.68	NCR, Delhi.

*During 2017, PDZM-31 was recommended for Zone II comprising of Rajasthan, Punjab, Haryana, Plains of Jammu & Kashmir, Delhi and western Uttar Pradesh.



Fig. 4. Pusa Karishma-India's first low erucic acid or '0' variety of Indian mustard



Fig. 5. PM 30- A bold seeded single zero variety of Indian mustard

requirements of low erucic acid (<2%) are called as single zero or '0' whereas, single zero varieties having glucosinolate content < 30 $\mu\text{mol/g}$ of oil-free meal are known as double zero or '00' or simply as canola type.

Indian rapeseed-mustard breeding programme was reoriented to accommodate quality parameters and lay emphasis to develop 'Canola Quality' Indian mustard varieties. In our country, the work on quality oil was initiated during 1997 under the network project established by the Indian Council of Agricultural Research (ICAR) with Indian Agricultural Research Institute (IARI) as a major center. Now improved varieties of Indian mustard having a very high yield potential with the improved oil and meal quality are available. IARI has been a pioneer in developing the India's first low erucic acid or '0' variety of *Brassica juncea* viz. Pusa Karishma which was released and notified during 2005. Subsequently, another five low erucic acid ('0') varieties and a maiden variety with low erucic as well as low glucosinolate traits ('00') with added characters of bold seed size and higher yield have been released from IARI. In a quality conscious society and consumer preference, it is expected that the low erucic acid oil producing varieties of mustard are likely to fetch at least ₹ 300-500 additional benefits per 100 kg of mustard to farmers while oils can attract premium price on the market shelves accordingly. Thus, these mustard varieties of IARI are a boon to farmers by fetching more profit per unit area in addition to providing consumers with higher

health value for the oils from these varieties. All these varieties have been recommended for timely sown irrigated conditions. Punjab Agricultural University (PAU), Ludhiana has also released a few of low erucic acid genotypes of *Brassica napus* (GSC5, 6 and 7) and double low *B. juncea* (RLC3). Specific features of varieties released from IARI are given in Table 2.

FUTURE CHALLENGES

Edible oil consumption is expected to grow to 24 kg/caput by 2020. Due to a large gap in the demand and supply of edible oil, India relies heavily on the import of edible oil to meet her domestic requirements. During 2016, India has imported 35 thousand tonnes of Canola oil worth \$32.7 million from Canada alone. Indian breeding programme towards enhanced oil and meal quality has come up in a notable way; still a lot of innovations spanning over research, extension and policy framework are needed to come up to the international benchmark.

- Urgent need for hands on training of scientist and technician involved in *Brassica* breeding regarding analytical tools and techniques such as gas chromatography, mass spectrometry etc. applicable in quality breeding.
- Private sector sponsored funding, besides increased funding from public sector to strengthen the infrastructure.
- Awareness drive in different stakeholders such as industry, consumers and farmers to promote indigenous single low and Canola quality mustard.

- Revision of custom tariffs to restrict low duty import of refined Canola oil to promote locally made Canola quality oil.
- A premium must be ensured through MSP as an incentive to promote the farmers for cultivation of single/double zero varieties of rapeseed mustard.

SUMMARY

Concerns about the detrimental health effects of *trans* fatty acids have led to a growing interest in using *trans*-free natural vegetable oils for deep frying food. Studies pointing towards health benefit of mustard oil have inclined consumers towards its use in domestic cooking. The widening gap between demand and supply of mustard oil has to be curtailed. At present enormous foreign exchange is being utilized in importing Canola oil. Canola-quality Indian mustard (*Brassica juncea*) is being developed as a complimentary oilseed crop to canola (*Brassica napus*). Successful breeding of six Canola quality at IARI, New Delhi and a few by PAU, Ludhiana, have been able to thwart the biggest challenge of combining the double low characteristics with good yielding capability, all of which are quantitative traits governed by multiple recessive genes. The oil that has been made qualitatively superior for human consumption, is a rich source of protein.

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