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- AMIT TOMAR

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QUALITY IMPROVEMENT IN OILSEED BRASSICA

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AMIT TOMAR
Teaching/Research Associate,
Department of Genetics & Plant Breeding,
Rani Lakshmi Bai Central Agricultural
University, Jhansi-2884003, U.P., India

QUALITY OF RAPESEED-MUSTARD OIL & SEED MEAL (Best for nutritional security)

Rapeseed & mustard oil contains lowest level of saturated fatty acids among all vegetable oil, which is quite desirable for good health. Both the essential fatty acids (EFA) such as linoleic acid (C18:2) and linolenic (C18:3) are present in rapeseed-mustard oil. Rapeseed-mustard oil has high level of antioxidant, which retards growth of free radicals mainly responsible for disease like cancer and ageing. Glucosinolates present in seed meal has shown anticancer properties. *Brassica* species are very rich in phenolic compounds and glucosinolates.

GENETICS OF ERUCIC ACID

Genetic control for erucic acid and its inheritance is different in various *Brassica spp.* Genetic studies have demonstrated that the erucic acid content in rapeseed-mustard is control by multiple alleles, Homozygosity levels between 5-10, 10-35 and >35% erucic acid have been reported (Jonsson, 1977). These are control by alleles in one or two and two loci, respectively. Two genes showing no dominance and acting in an additive fashion have been implicated for erucic acid content in *B. juncea* (Kirk and Hulstone 1983; Meena and Sachan 2009; Singh *et al.*, 2010).

GENETICS OF GLUCOSINOLATES

Genetic analysis from the segregating populations of various crosses involving Bronowski has suggested the involvement of as many as 11 recessive alleles (Kondra and Stefanson, 1970) conditioning the low values of 3-butenyl 1-4-pentenyl-and 2-hyrdoxy-3-butenyl glucosinolates. Genetic control of total glucosinolates in *Brassica juncea* has been reported to be under two major genes (Love *et al.*, 1990a).

Quality improvement

Rapeseed-mustard cultivar contains very high level of erucic acid (45-60%) in oil and high level of glucosinolate (120-180 μ mole / g) in oil free meal. High percentage of erucic is undesirable from nutritional point of view for human being and high glucosinolate in oil free meal is considered to be growth inhibiting factor and may lead to carcinogenic effect in animals when used as feed. The breeding programme for oil quality improvement in Rapeseed-mustard to reduced erucic acid content < 2% and glucosinolate contents < 30 μ mole / g in oil free meal. Pusa Karishma, Pusa mustard-21 and RLC-2 varieties of Indian mustard has been released for zone II which having < 2% erucic acid.

The oil in rapessed-mustard is characterized by high level of erucic acid. The feeding experiments on animals during 1950s revealed that nutritional value of oil could be significantly enhanced by reducing erucic acid to less than 2%. Erucic acid, linoleic acid and oleic acids are the major fatty acids. Erucic acid constitutes about 50% of the total fatty acid in the traditional rapeseed-mustard varieties and has been reported to be associated with many physiological and metabolic disorders. As such it had been the major target for genetic elimination. Plants with genetic block in biosynthetic pathway towards eicosenoic acid-erucic acid were first identified in summer rape (Stefansson *et al*, 1961), turnip rape and then in Indian mustard (Kirk and Oram, 1981). Half seed non-destructive screening technique is routinely applied in backcross programmes to transfer genes preventing synthesis of erucic acid into agronomically superior recurrent parents (Jonsson, 1973; Morice, 1974). As a result of availability of well defined gene sources and non-destructive screening procedures, low erucic acid varieties have been bred in Indian mustard also. Due to a comparatively simple inheritance (major genes) with additive genetic effects, besides availability of rapid, non-destructive screening techniques (e.g. half seed methods, excellent analytical techniques and gene sources) fatty acid composition of elite commercial strains could be easily tailored using various modifications of standard backcross procedure (Banga, 1996). Efforts are made to develop canola varieties which possess internationally accepted quality having 2 % erucic acid and 30 µ moles glucosinolates/g in defatted meal or cake the promising varieties are EC 287711, QM 14, Shiva, Nihar and TER 7. These are being further improved for higher yield and other agronomic traits and are being tested at NDDB.

Palmitic acid (C 16 : 0) → Stearic acid (C 18 : 0) → Oleic acid (C 18 : 1) [Ecosenoic acid (C 20 : 1) → Erucic acid (C 22 : 1)] → Linoleic acid (C 18 : 2) → Linolenic acid (C 18 : 3).

Fig.-1: Biosynthesis pathway of main fatty acid in Rapeseed-mustard. *Jonsson (1977).*

Table-1: Original gene sources for desirable quality traits.

Character	Species	Genotypes	References
Low erucic acid	*B.compestris*	Polish cultivar Sv. Torpe, Sv. Bele	Downey (1964) Jonsson (1977)
	B. napus	Liho	Stefansson *et al.*(1961)
	B. juncea	Zem-1, Zem-2	Kirk and Oram (1981)
Low linolenic acid	*B. napus*	Mutants of Oro	Rakow (1973) Roy and Tarr (1986)
High linoleic acid	*B. napus*	Breeding material	Jonsson and Uppstrom (1986)
Low glucosinolates	*B. napus*	Bronowski	Josefsson and Appelqvist (1968)
	B. compestris	Sv. Polish	Downey *et al.* (1969)
Low sinapine	*B. compestris*	Sv. 83-36505Sv. 83-36531	Uppstrom and Jonsson (1985)

Table-2: Low erucic acid and double low varieties of rapeseed mustard released in India.

Variety	Pedigree	Breeding method
Brassica juncea		
LES-39 (Pusa Karishma)	Pusa Barani x Zem-1	Backcross
LES-1-27 (Pusa Mustard 21)	Pusa Bold x Zem-2	Backcross
LET 18 (Pusa Mustard 24)	(Pusa Bold x LEB 15) X LES 29	Pedigree selection
LET-17 (Pusa Mustard 22)	Pusa Barani x Zem-2	Backcross
Brassica napus		
GSC 5	Hyola 401 x (Agat x GSL-8888)	Pedigree selection
OCN-3	(NECN 13 x Tribute) x NECN-13	Backcross
PAC-401	44002A x 4154 R	CMS based hybrid
NUDH 26-11	Selection from germplasm	Pure line selection
TERI Uttam Jawahar [TERI (00) R 9903]	-------	------

Table-3: Sources of various quality traits.

Quality traits	Species	Donor
Low glucosinolate (<30 micro moles/g defatted seed meal)	*Brassica juncea*	NUDHYJ-1, NUDHYJ-2
Low glucosinolate (<30 micro moles/g defatted seed meal)	*Brassica napus*	HNS-99 (0E)3, NUDB-9
Low erucic acid (<2%)	*Brassica juncea*	**LES-17-1, Pusa Karishma (LES-39), LES-1-27 (Pusa Mustard 21), LET-17 (Pusa Mustard 22), LET-18 (Pusa Mustard 24), LET-36, YSRL-9-18-23, TERI (0E) M21 (IC-296684), ELM-079, ELM-123, PRQ-2005-1 (IC-546946)**
Low erucic acid (<2%) and low glucosinolate (<30 micro moles/g defatted seed meal)	*Brassica juncea*	BJ-1058, NUDH-YJ-5 (IC-296507), Heera (IC-296501)
Low erucic acid (<2%) and low glucosinolate (<30 micro moles/g defatted seed meal)	*Brassica napus*	BCN-14, CAN-138, GSC-5, OCN-3, NUDB-26-11, TERI (00) R985 (IC-296732), TERI (00) R986 (IC-296731), TERI (00) R-9903 (IC-404233), PAC-401, NUDB-38 (IC-296827), NUDB-42 (IC-296818)
High oleic acid (70.2%) with low erucic acid (<2%)	*Brassica rapa*	PHOP-2-2 (IC-552726)
High oleic acid (70.2%) with low erucic acid (<2%)	*Brassica napus*	TERI (0E) R03 (IC-296685), TERI (0E) R09 (IC-296686)
High oleic and linolenic acid	*Brassica juncea*	TERI GZ-05 (IC-404233)
Low linolenic acid (3.03%)	*Brassica rapa*	PHOT-8-2-11 (IC-552726)
High oil content (~ 45%)	*Brassica juncea*	NDYR-8 (IC-296689), NDYR-10 (IC-296689)

QUALITY AND QUALITY FACTORS IN RAPESEED AND MUSTARD:

Rapeseed and mustard oil is the most important edible oil in North India which is difficult to be replaced by any other oil. The oil content of most of the types ranges between 30-48 per cent; however, in white mustard it is hardly 25-33 per cent. The seeds and oil are used as condiment in preparation of pickles and for flavouring curries and vegetables. The cakes are usually used as cattle feed and it is rarely used as organic manure though it has high manorial values. The young plants or their leaves are often used as green vegetables. Its industrial uses are very limited due to very high cost, though superior quality greases may be prepared from its oil. In old days its oil was used as lamp oil but now it is hardly found for edible purposes.

Factors affecting quality of mustard oil:

1. **Genetic factors:** The oil content varies according to genotypes or plant type viz. Yellow sarson and brown sarson contain 35-48 per cent oil, toria 33-36 per cent, and 'rai' contains only 30-42 per cent oil. Similarly, erucic acid content, oleic acid and linoleic acid content also vary from type to type. Protein content and extent of toxic glucosinolates content differ from type to type and product to product viz., 24-30 per cent on the whole seed basis and 35-40 per cent on meal basis.

2. **Moisture content in the seed:** The oil extracted from seeds having high moisture content is found to be of poor quality compared to oil extracted from the seed of low moisture content. The oil with more moisture becomes rancid soon and has relatively poor keeping quality. The oil per cent in the seed having higher moisture is also found to be low.

3. **Effect of nitrogen fertilization:** Nitrogen increases seed yield but depresses oil content in them. The protein and glucosinolate contents in seed are also found to be affected with nitrogen fertilization. Nitrogen is found to increase the protein and glucosinolate content in seeds of both rapeseed and mustard. Therefore, application of more than required quantity of nitrogen is bad, though it increases seed yield and growers are benefited with this practices. Application of nitrogen at bud formation stage or at flowering stage in some cases has been found to increase the grain yields as it increases size of pods and grain weight but there is no substantial proof for this finding.

4. **Effect of phosphate fertilization:** Phosphorus increases oil content in the seeds and it is observed that under extreme deficiency of phosphorus the oil content in seed is found to drop from 33 to 23 per cent. The influence of phosphorus on fatty acid composition appears to be very low. As light increase in oleic acid content has been noticed due to phosphorus application but this had no significant value. Similarly, phosphate fertilization increased the amounts of oleic, linoleic, linolenic and eicosenoic, with an appreciable decrease in undesirable erucic acid content. The protein content of mustard seeds was either not affected or slightly affected with phosphate fertilization. But under the conditions of sulphur deficiency it increased the free amino acid contents, particularly that of proline and arginine. Glucosinolate content is expected to be reduced due to phosphate application; however, a very small reduction has been noticed.

5. **Potassium fertilization:** Crop response, either in terms of yield or quality, to applied potassium has not been noticed which could be due to presence of higher potassium contents in the soil. Its response is noticed only on soils of low or very low potassium status however, the increase in oil content is found to be statistically non-significant. The fatty acid composition was not changed with potassium application. An inverse correlation between protein and oil content in mustard has been noticed and since the oil content and composition are not affected due to potassium, therefore, it is assumed that protein is also not affected due to potassium. Overall it may be concluded that potassium had a negligible effect on the quality of mustard.

6. **Effect of secondary and micro-nutrients on yield and quality of mustard:**

Sulphur did not show any positive response on yield of mustard grains but no sulphur treatment had particularly low sulphur status and lower oil content, while in other reports a depressed oil content was noticed where sulphur was applied. Sulphur application tended to increase it during the early stage but had little effect on composition in matured seeds. Under deficient sulphur supply an increase of about 6 per cent in oleic, acid and a decrease of about 9 per cent in erucic acid was noticed. The sulphur deficiency appears to inhibit the elongation of fatty acid chain from 18-22 carbon atoms. Sulphur showed very little effect on total protein content but it can have greater effect on amino-acid composition. Sulphur application in deficient soils decreased the methionine slightly and cystine content was doubled, while threonine and aspartic acid, from which the carbon chain of methionine can be derived, decreased. A reduction in arginine content was the only other appreciable effect of sulphur on amino-acid content. Sulphur nutrition showed a market effect on the glucosinolate content in the treated seeds. At low levels of sulphur nutrition Brassica species produces very little glucosinolate and it was observed that the effect of sulphur supplies was much greater on glucosinolate content than on sulphur containing amino acids. Thus sulphur supplies increase the glucosinolate content of seeds. The glucosinolate and its hydrolysis products such as allyl-isothiocynate (in brown sarson) and p-hydroxybenzyle isothiocynate (in white mustard) which are desirable for higher pungency, as detected by organolectic tests, in mustard powder are found to be increased with increase in sulphur supplies. Calcium application did not show any effect, neither positive nor negative, on the oil content and its quality. Poor Magnisium nutrition shows a reduced sinigrin content of the brown mustard and it may, therefore, reduce its suitability for use in condiments. Boron application reduced the erucic acid content significantly but oil content and its composition as related to fatty acid content was not affected with Boron fertilization. Response of mustard to other micro-nutrients on its yield and quality is very little studied and hence informations regarding such aspects are lacking.

7. Weather conditions during grain filling stage: The synthesis of oil in grain begins immediately after the ovary is fertilized and it goes on developing the development of seeds towards maturity. Thus the rate of oil formation depends upon the meterological conditions. Under normal temperature conditions the most rapid development of oil begins when the seed is about 20 days old and continues for another 20 days.

8. Oil quality as influenced by adulterants: The most common adulterants of mustard oil are groundnut and linseed oils. Sometimes taramira oil is also mixed with mustard oil. The choice amongst these three, however, is decided by the relative prices of these adulterants as compared to mustard oil. The other adulterants, though very rarely used are sesame oil, niger oil and even mineral oil. The cheapest adulterant of all is the Mexican poppy (*Argimone maxicana*) seed which is mixed with mustard seeds during harvesting time. The *Argimone* oil has a nauseous and acid taste and its use causes epidemic dropsy (Ind. Med. Gaz. 81, 1946). The cyanide compound present into it produces poisoning, if consumed, and results into beri-beri disease in human beings. Thus the quality of oil, flavour etc. Changes with the relative proportion of adulterants into rapeseed or mustard oil.