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A review of various quality enhancement strategies in soybean and rapeseed

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ABSTRACT

Oilseed crops are grown primarily for the oil contained in their seeds. The major oilseeds grown are soybean, sunflower, canola and flax. The oil content of grains (e.g, wheat) is only 1-2%; that of oilseeds ranges from about 20% for soybeans to over 40% for sunflowers and rapeseed (canola). Majority of the oilseed meal consists of proteins and high contents of essential amino acid which are beneficial to human health and wellbeing. Likewise, the fat yields of oilseed crops are generally high, though varied from crop to crop (specie), and methods of extraction; high polyunsaturated fatty acids contents also prevent against coronary heart disease. Oilseed crops are promising crop with high potentials to improve human diets, prevent malnutrition and food insecurity and to provide employment through income generation in the society. Major objectives in oil crop improvement are reducing the content of two harmful substances, erucic acid and glucosinolate, which were formerly a problem in rapeseed oil and quality enhancement in soybean. Oilseeds are in demand globally, and there is a need to identify and quantify the key issues for their seed quality enhancement to develop and support actions that will ensure a viable future of such crops.

Keywords: Erucic acid, Glucosinolate, Oilseeds, Seed Quality Enhancement..

I.INTRODUCTION

India is one of the major oilseeds grower and importer of edible oils. Oilseed crops are primarily grown for edible oil. Among the oilseed crops, rapeseed/mustard ranked next to ground nut (*Arachis hypogaea* L.) and soybean (*Glysine max* L.) in contribution to the oilseed production. Recently, oilseeds attracted more attention due to an increasing demand for their healthy vegetable oils, livestock feeds, pharmaceuticals (María P. Sosa-Segura *et al.,* 2014), biofuels (Singh and Nigam; 2011), and other oleo chemical industrial uses. Seed oils can be used for different purposes: for human consumption as food (Mohamed Fawzy Ramadan; 2011) for cooking

(Mounts, Warner, List, Neff, & Wilson, 1994), as a source of bioactive compounds and/or nutraceuticals (e.g. vitamins, polyphenols) and for using in the pharmaceutical and cosmetic industries for preparation of different products. Mustard has been a traditionally important oilseed crop in the India. It is a major Rabi crop. Cultivation of mustard is between October-November and February-March. Major growing areas are Rajasthan, Uttar Pradesh, and Haryana. Broadly seven varieties of mustard rapeseed are grown in India. Most popular varieties grown in Indian subcontinent are *Brassica juncea*, *Brassica campestris* and *Brassica napus* L.. The increased interest resulted in an 82% expansion of oilseed crop cultivation areas and about a 240% increase in total world production over the last 30 years. Therefore, to satisfy the increasing world demand, sustainable oil production, through classic breeding efforts needs to be coupled with biotechnological approaches in order to expand oil yield per unit area. The expansion of oilseed growing areas can be another approach utilized to meet this increased demand. Genetic engineering of oilseeds will allow not only the sustainable production of oilseed crops but also enhanced nutritional value as well as enhanced quality for industrial purposes. TAGs, composed of various fatty acids, are the main component of vegetable oil. Many genes in TAG biosynthesis pathways have been identified and studied well. New biotechnology methods allow insertion or modification of genes involved in the biosynthesis of a desired fatty acid, in order to accumulate a higher level of fatty acid or even to produce a novel fatty acid. Genetic engineering started a new era for designer oil crops and has created opportunities for sustainable oilseed crop production around the world (Mukhlesur Rahman *et al.,* 2016). Oilseed crops play the second important role in Indian economy next to food grains in terms of area and production. The major oilseed crops grown worldwide are: soybean, rapeseed, cottonseed, peanut, sunflower seed, palm kernel, and copra (Daun, Eskin, & Hickling, 2011).

II.ENHANCEMENT STRATEGIES FOR QUALITY IN MAJOR OILSEED CROPS (SOYBEAN AND RAPESEED)

Various conventional methods have been exploited for enhancing the yield of oilseeds crops, however, for further improvement there is a need to adopt recent technologies, which will lead to improved sustainability.

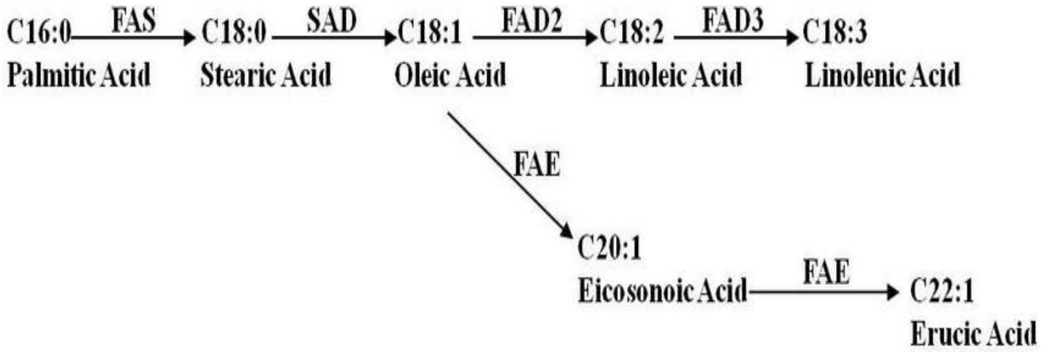
a) Soybean: Beany taste in soybean is due to sulfur compound. Soybean is called as wonder crop. The economic product of soybean crop is Oil, so called as oilseed crop. It contains 40-42 per cent protein and 20-22 per cent oil. Soybean contains the poly-unsaturated fatty acid – Linolic acid & Oleic acid. Soybean breeders have made significant progress in improving the overall yield of soybean, which translates into more protein and oil on a per ha basis. Despite this, minimal advancements have been made in the selection of high-yielding genotypes, with major shifts in carbon flux for improvements in total oil or protein content (Mahmoud *et al.,* 2006). On the other hand, implementing the tools of molecular biology and biotechnology has opened the door to the development of improved end-use quality of the oil for food, feed, and industrial applications. These have been achieved by directed modification of fatty acid biosynthesis to alter relative amounts of fatty acids naturally found in soybean or to produce novel fatty acids (Jaworski and Cahoon, 2003; Damude and Kinney, 2008). In case of Soybean high amount of polyunsaturated fatty acids is a major limiting factor in terms of quality. A possible approach for improvement of oil quality in soybean is the inactivation of fatty acid desaturase genes (*FAD-2-1* and *FAD-2-2*). (William Haun *et al.,* 2014). In a similar study conducted by Nicole Bachleda *et al.,* 2017 an attempt to improve oleic acid content in soybean seed which is considered to be key compositional trait that improves oxidative stability and increases oil functionality and shelf life. Using a marker- assisted selection method, near -isogenic lines (NILs) of G00-3213 were developed and yield tested for the high oleic trait. The results indicated that G00-3213 NILs with both homozygous mutant *FAD2- 1A* and *FAD2- 1B* alleles produced an average of 788 g/kg oleic acid content. The results also demonstrated that possessing these mutant alleles did not cause a problem in yield reduction. Unpleasant beany flavour is another problem in soybean (Nandanie *et al.,* 1987). This problem has been addressed through mutagenesis and one mutant lax-2 which totally inactivates the enzyme. (C. S. Davies *et al.,* 1987). A study conducted by Kyung Jun Lee *et al.,* 2014 revealed the elimination of lipoxygenases can reduce the poor stability and off-flavours of soybean oil and protein products. In this study, a soybean mutant (H70) was selected in which the three lipoxygenases had been mutated using gamma rays. The results suggest that gene analysis based on DNA sequencing could be useful for elucidating the lipoxygenase content in soybean mutant lines. Additionally, the soybean mutant line selected in this study could be used to develop soybean cultivars with improved flavour.

b) Rapeseed: The brassicas commonly known as rapeseed mustard are important group of edible oils and vegetables crops belonging to Brassicaceae or Cruciferae family. Rapeseed mustard is the third most important source of vegetable oil in the world and is grown in more than 50 countries across the globe. For breaking the yield barrier, population improvement programme was followed involving diverse parents. Through the intervention of biotechnological tools, yield QTLs are to be identified and can be introgressed in improved backgrounds using marker-assisted selection (MAS) **(**D. K. Yadava *et al.*, 2012**).** A major problem with mustard oil is that it contains large amounts of erucic acid (50%) and glucosinolates (80-160 micromoles/g), even though it is relatively stable by virtue of having less polyunsaturated fatty acids (Christine wendlinger *et al.,* 2014, Hussam *et al.,* 2017). Serap Durakli Velioglu *et al.,* (2017) in their study revealed a novel method to determine erucic acid in canola oil samples by using Raman spectroscopy and chemometric analysis. The oil mixtures were prepared at various concentrations of erucic acid ranging from 0% to 33.56% (w/w) through binary combinations of different oils. In order to predict erucic acid content, Raman spectroscopy and GC results were correlated by means of partial least squares analysis. The results revealed the potential of Raman spectroscopy for rapid determination (45 s) of erucic acid in canola oil. According to Katherine Cools *et al.,* (2018) three mustard seed cultivars from two seasons were processed into Dijon- and wholegrain-style mustard and glucosinolates and isothiocyanates were analysed. Canadian cv. Centennial tended to contain higher glucosinolates compared with the French cv. AZ147 and Ukrainian cv. Choraiva. Conversion of the mustard seed into a wholegrain condiment had less effect on total isothiocyanates and sinigrin content compared with the Dijon preparation. The Canadian mustard cultivars produced wholegrain-style mustard with higher total isothyocyantes and sinigrin compared with the French and Ukrainian cultivars. Therefore, results suggest that

Canadian mustard seed cvs. Centennial and Forge, and wholegrain processing results in a condiment with greater bioactive composition. Hussam *et al.*, (2008) revealed that glucosinolates are sulfur-rich secondary metabolites characteristic of the Brassicales order. He studied, piecing together the glucosinolate pathway by presenting and critically analyzing all data on glucosinolate research. Furthermore, the data on glucosinolate transport is considered in the light of the newest findings on glucosinolate synthesis and distribution. The aim of this study was to provide a comprehensive and updated set of hypotheses which may prove useful in directing future research on glucosinolate transport.

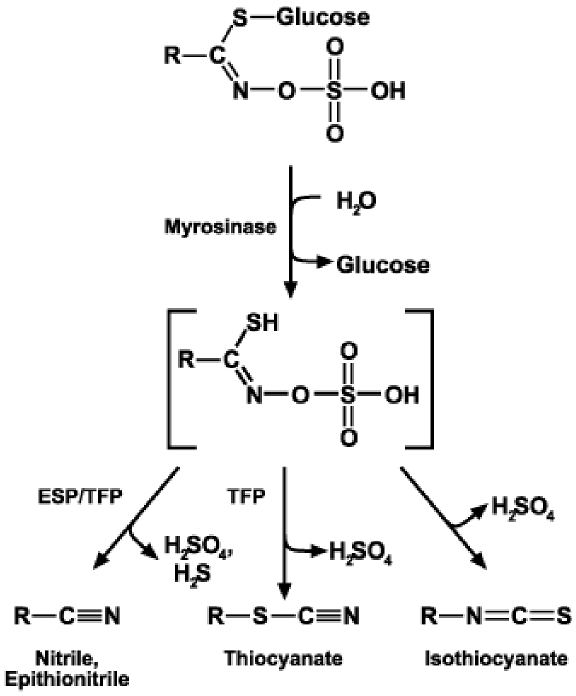
Pathway of Fatty Acid Biosynthesis:

Fig.1



Glucosinolate Metabolism:

Fig.2



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