Plant Breeding and Rape Seed Oil

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The modifications performed of the fatty acid compositions of our oil crops as demanded by the consumers and the market are excellent examples of the success of plant breeding. This has not least been demonstrated by the modifications performed of the fatty acids in oil seed rape, during the 60's and 70's. After the second world war an increased need and demand of crops cultured for production of edible oils developed within Western Europe and Canada. This demand is maybe even larger today where very specific requirements regarding the tailoring of the fatty acid profile in the oil crops have been formulated by nutritionists and the industrial market. As in the start when breeding began to meet the specific demands for oil crop cultivars, consultations and communications between the consumers and the breeders were and still are of largest importance to guideline the breeding priorities.

Selection from available germplasm.

The first cultivars of oilseed rape used for production of edible oil contained high amounts of erucic acid. The suspicion that erucic acid could be detrimental for health in animals as well as in humans (Beare, 1957) stimulated to an intensive breeding of existing rapeseed cultivars. Today we can see the positive results from these breeding efforts. By utilizing the variability of fatty acid composition present within the cultivars at that time and screen for individuals with low amounts of erucic acid new varieties were found (Stefansson and Hougen, 1964). This screening would not, however, have been efficient without a concomitant development of sensitive and rapid analysis methods e.g. NMR and gas chromatography, as well as the development of the half-seed technique (Downey and Harvey, 1963). The varieties found by the Canadian breeders, having low erucic acid content, were later on utilized in the breeding for other varieties with low erucic acid e.g. in Germany, France and Sweden.

Mutation Breeding.

Even though a genetic blockage in the elongation between C 18:1 and C 20:1 resulted in an accumulation of the precursor oleic acid, which also lead to higher levels of linoleic and linolenic acids, these were still too low compared to the oil composition in other crops like soybean and sunflower oil. Furthermore, presence of rather high levels of linolenic acid made the oil less valuable. This stimulated the breeders to continue their efforts and breed for higher contents of specific polyunsaturated fatty acids, linoleic acid. Inspite of a vast screening of a large number of cultivars and species the desired variability could not be found (Thies 1968). Then mutation experiments were conducted in order to produce genotypes impossible to find in nature. Large scale mutation experiments were initiated in Germany by Rōbbelen and Rakow and in France by Morice. Mutants were obtained expressing low levels of linolenic acid (Rakow, 1975), which later on were utilized in further breeding programs to exclude the deleterious effects from the exposure to the mutagens, but also to combine the desired traits of low linolenic and high linoleic acid content.

Seed-specific targeted modifications of fatty acids.

The substantial modifications performed of the fatty acid composition by traditional plant breeding techniques are encouraging for further improvements of the oil composition in our crops. The changes induced have been possible to obtain without significant reductions in other properties of the plant e.g. viability and yield. Thus, these results prove that changes will be possible to induce in the storage lipids without affecting the composition of fatty acids in other parts of the plant e.g. the membranes of leaves and roots. A common feature for the modifications obtained using traditional breeding strategies is, however, that it is only the levels of the fatty acids produced, that are altered, mainly due to reductions in enzyme activities or due to elimination of the gene coding for the enzyme. Thus, the possibilities for modifications like production of novel fatty acids or enhancing activity of an already present enzyme regulating biosynthesis of a specific fatty acid are limited. To obtain such changes genetic engineering might be the method of choice. By using the techniques of genetic engineering new genes coding for novel traits can be introduced into a crop and enzyme activities can both be suppressed and enhanced.

Cell biology and genetic engineering.

A fundamental knowledge of the biosynthetic pathways involved in the synthesis of storage lipids is the foundation for which breeding strategy and modification to do when trying to change the fatty acid composition in the crop. A rather detailed description of the enzymes involved in the fatty acid biosynthesis and in particular synthesis of the storage lipids exist today (Sommerville and Browse, 1991, Stymne 1992). However, the precise knowledge about which key enzymes that regulate the processes, the structural genes that codes for these enzymes and the regulatory elements involved in the different steps are the major hindrances for utilizing genetic engineering for the desired modifications. Nevertheless, an intensive research and rapid development go on within this area. These in combination with the fact that Brassica species are particularly amenable to several cell biological techniques including cell culture, somatic hybridization and genetic transformation are promising for the future and several new ways to modify the storage lipids in rapeseed have been opened.
Utilization of microspore culture for production of homozygous lines and for studies of fatty acid inheritance has been reported (Chen and Beeversdorf 1990). Furthermore, somatic hybridization can be used for transferring genes involved in fatty acid biosynthesis from a wild species not possible to cross with rapeseed by sexual means (Glimelius et al. 1991). Besides this, modifications of seed specific fatty acids by genetic engineering have recently been published (Knutzon et al. 1992, Voelker et al. 1992.). Even though these modifications do not involve changes of importance for nutritional aspects they are promising examples of the future potentials for utilizing cell biology and genetic engineering as complements in the breeding of our oil crops.

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