Breeding for improved fatty acid composition in rapeseed

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Originally oils of rape and turnip rape differed markedly from those of other primary margarine materials by their high contents of eicosenoic and erucic acid, the latter in very large amounts. These oils also contained comparatively large amounts of linolenic acid and small amounts of linoleic and palmitic acid. However, the quality of rapeseed oil has been considerably improved by plant breeding.

Because of the risk that erucic acid may cause fatty deposition in muscles and myocardial lesions this fatty acid is undesirable in edible oils. However, genes for low erucic acid have been found first in Brassica napus and later on also in B. campestris. Today low erucic varieties of both rape and turnip rape are grown in many countries and except for the transition period the change to low erucic acid varieties has been realized without any drop in yield capacity. By removal of the erucic acid also the eicosenoic acid content was reduced to a low level. The improvement of the oil quality has made possible a continued rapeseed growing and a continued use of rapeseed oil as an edible oil. Genes for low erucic acid are now found also in B. oleracea, B. juncea and Sinapis alba.

The reduction of erucic and eicosenoic acid in rape and turnip rape to a very low level gave a drastic rise in oleic acid to about 55 %, a comparatively strong rise in linoleic acid to about 22 % and a minor rise in linolenic acid to about 12 %. In order to enhance the usefulness of rapeseed oil as raw material for margarine production a further increase of the amount of the essential linoleic acid to 40-50 % is desirable. The linolenic acid is easily oxidized, resulting in taste impairment, and the amount of this fatty acid should therefore be kept at a minimum in margarine.

Rapeseed oil of the low erucic acid type has a very homogeneous fatty acid composition. About 90 % of the fatty acids belong to the C 18-group and a consequence of this is undesirable changes of the physical characteristics in the hydrogenated oil. The earlier type

of hydrogenated rapeseed oil crystallizes with a relatively stable β'-form, whereas hydrogenated oil of the low erucic type has a strong tendency for transition into the stable β-form. A margarine containing hydrogenated rapeseed oil of the low erucic type may therefore, upon storage, change to an unacceptable texture, which gives a sandy taste in the mouth (Hernquist and Anjou 1983). In margarine produced from oils with more varying chain lengths this problem does not arise. Therefore a low erucic rapeseed oil with an increased content of palmitic acid, C 16:0, to more than 10 % is wanted.

Further improvement of the rapeseed oil can be achieved by plant breeding. Many years ago a breeding program for increased content of linoleic acid in winter rape was started at Svalöf. Repeated selection for some generations resulted in a material with 35 % linoleic acid as an average and with extreme values up to 40 % in single seeds. In general these extremes had increased content of linolenic acid too. However, a few seeds with 35 % linoleic and 8-10 % linolenic acid were found. In another material seeds with less than 5 % linolenic but with a normal content of linoleic acid were found. In these winter rape materials a positive correlation existed between the contents of linoleic and linolenic acid. Also a rather strong environmental influence on these fatty acids was observed.

The above mentioned material with 35 % linoleic and 8-10 % linolenic acid was at Svalöf crossed with a German mutant with about 30 % linoleic and 3-4 % linolenic acid (Röbbelen and Nitsch 1975). In the progeny the variation in fatty acid composition was further increased and by repeated selection stable lines with more than 40 % linoleic and 3-4 % linolenic acid have been found. Results from crosses with these lines indicates that each of these fatty acids is controlled by only one or two pair of non-dominant genes. Also the environmental influence on these genes seems to be rather limited. Some lines in this material also have increased content of palmitic acid up to 10-11 %.

The genes for very high linoleic and very low linolenic acid content have been transferred to well-adapted, low erucic materials of both summer and winter forms of rape and turnip rape. The variation found in single seeds in some F_1-materials of winter rape is shown in table 1. Unexpectedly high contents of linoleic and palmitic acid and low contents of linolenic acid were found already in the F_1-generation. In a few cases the content of linoleic acid even surpassed that of the best parent. In F_1 also palmitic acid contents up to 11 % and oleic acid contents up to 76 % have been found. Some seeds had an oil quality very similar to that of soybean oil. Theoretically an increased variation in fatty acid pattern is expected in the F_2-generations.

Breeding work for further improved oil quality has been carried out also in the low erucic breeding material of summer turnip rape

Table 1. Variation in fatty acid pattern found in F_1-seeds of winter rape.

Material	Fatty acid, % Palmitic C 16	Oleic 18:1	Linoleic 18:2	Linolenic 18:3
Herkules (market variety)	5	58	23	12
High 18:2 x Low 18:3	10	30	47	9
Double-low x(High 18:2,low 18:3)	11	35	44	11
- " - x(- " -)	8	48	37	5
(Double-low x Jupiter)x(- " -)	6	40	46	7
(- " - x Emil)x(- " -)	5	58	33	3
(- " - x ")x(- " -)	7	46	42	3
(- " - x ")x(- " -)	8	27	45	18
Jupiter x(- " -)	5	76	11	6
Soybean oil	11	25	49	8

at Svalöf. By repeated selection on single plant and single seed level a still bigger differentiation in fatty acid composition, than in the winter rape materials mentioned above, has been discovered. Some interesting fatty acid patterns found in summer turnip rape are given in table 2. Contents of linoleic acid up to 51 % and of lino-

Table 2. Variation in fatty acid pattern in breeding materials of summer turnip rape in comparison to the varieties Bele and Tyko.

Fatty acid		Fatty acid, % Bele	Tyko	Breeding material				
C 16:0	Palmitic	2.7	4.2	4.5	8.3	3.0	12.6	2.7
C 16:1	Palmitoleic	0.3	0.3				5.2	0.0
C 18:0	Stearic	1.3	1.1	31.1	61.8	80.2	1.0	5.8
C 18:1	Oleic	26.9	57.9				41.7	66.9
C 18:2	Linoleic	16.7	22.9	51.1	26.9	9.4	20.4	14.0
C 18:3	Linolenic	9.0	12.0	12.3	3.0	4.5	17.6	5.5
C 20:0	Arachidic	0.8	0.3				0.4	2.1
C 20:1	Eicosenoic	11.7	0.7	0.6	0.0	2.4	0.5	1.6
C 20:2	Eicosadienoic	0.6						0.1
C 22:0	Behenic	0.4	0.7		0.0		0.2	1.2
C 22:1	Erucic	27.5						
C 22:2	Docosadienoic	0.4						
C 24:0	Lignoceric	0.2						
C 24:1	Nervonic	1.5						

lenic acid down to 3 % were found. Besides some seeds contained up to 80 % of oleic and stearic acid. Still more interesting, however, is the material with a palmitic acid content of about 12 %. This material has been stable when grown under different conditions. In summer turnip rape also another interesting fatty acid material with high content of the saturated stearic acid was found. Also the contents of arachidic acid and behenic acid, both saturated, were somewhat increased in this oil indicating an increased activity in the biosynthetic pathway from palmitic acid → stearic acid → arachidic acid → behenic acid.

The breeding work carried out at Svalöf has revealed a very big variation in fatty acid pattern both in rape and turnip rape. The results obtained so far are very promising and probably the fatty acid composition in rapeseed oil in the future can be made very similar to, or in some respects even better than that of soybean oil. New qualities of rapeseed oil, adapted to various demands of the fat industry, can be developed by plant breeding.

References:

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