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Increase of erucic acid content in oilseed rape (*Brassica napus* L.) through the combination with genes for high oleic acid

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List of Abbreviations

Acc.	Accession
ACP	acyl carrier protein
AG	Aktien Gesellschaft
^{o}C	centigrade/degree Celcius
ca.	circa
cDNA	copy DNA
cm	centi metre
CoA	Coenzyme A
CoASH	Activated CoA
cv.	cultivar
DH	doubled haploid
DUE	Development for Undergraduate Education
et al.	Et aleri
etc.	Et cetera
EU-15	European Union-15
fad	fatty acid desaturase
fae1	fatty acid elongation
FAS	fatty acid synthethase
FFA	free fatty acid
g	gram
GH	a critical value to eliminate samples with spectral distance too far from the population mean
GLC	gas (liquid) chromatography
GSL	glucosinolate
ha	hectare
HEAR	high erucic acid rapeseed
HO	high oleic
HOAR	high oleic acid rapeseed
HOLL	high oleic low linolenic acid rapeseed
HPLC	high pressure liquid chromatography
ISI	infrasoft international
KCS	β-ketoacyl CoA synthase
kpa	kilopascal
L.	Linnaeous
LG	Linkage group
LL	low linolenic
LEAR	low erucic acid rapeseed

LPAAT	lysophosphatidic acid acyl transferase
max	maximum
µl	micro litre
µm	micro metre
mol	molar
µ mol/g	micro molar per gram
m	metre
M x E	Mansholt x Express
mg	milli gram
min	minimum
mm	milli metre
MPLS	modified partial least square
MUFA	mono unsaturated fatty acid
n	total number of sample
Na-methylate	sodium-methylate
nd	not determined
No.	Number(s)
NIRS	near-infrared reflectance spectroscopy
NPZ	norddeutsche pflanzenzüchtung
PtC	phosphatidyl choline
PUFA	poly unsaturated fatty acid
R239	Resynthesis line 239
ref.	reference
rpm	rotary per minute
r_s	Spearman's rank correlation
RSQ	Coefficient determination
RT	room temperature
SD	standard deviation
SEC	standard error of calibration
SECV	standard error of cross validation
SEP	standard error of performance
SEPC	standard error of performance after cross validation
slc1-1	sphingolipid compensation
sn-2	second position of the triacylglycerols backbone
SNV	standard normal variance
spp.	Sub species
SR	Spring rape
T	critical value is to eliminate the samples from the regression model
TAG	triacyl glicerols
UNSOED	University of Jenderal soedirman

USA	United States of America
1-VR	coeffiecient of determination after cross validation
VLCFA	Very long chain fatty acid
WR	Winter rape
X	critical value to eliminate the samples with unsual spectra

1 Introduction

1.1 Importance of rapeseed oils

Rapeseed (*Brassica napus* L.) is one among several important plants used as source of vegetable oils. At present, rapeseed oil is following soybean and palm oil in world production and is used for both nutritional and industrial purposes (Piazza and Foglia, 2001, Walker and Booth, 2001). Nutritionally, replacement of saturated fats/oil with unsaturated ones contained in vegetable oils on the daily diet could help to prevent from coronary heart disease (Freese, 2001), mainly by lowering serum cholesterol levels (see Velasco et al., 1999d). Fast growing demands of rapeseed oil as food source, therefore, is related to increased consciousness of healthy food (Murphy, 1994). Industrial use of vegetable oils, however, is more related to its different fatty acid contents. Sonntag (1995) stated that behenic acid (C22:0), and erucic acid (C22:1) have been applied substantially in the oleochemical industry.

In traditional *Brassica* oilseeds, the occurence of two components C22:1 and glucosinolates (GSL) traditionally distinguishes them from other major oil seeds (Lühs and Friedt, 1994). Since these two components are considered as antinutritional for both human and animals their contents were minimized by traditional breeding, which finally resulted in the release of Canola or '00' quality type. This rapeseed oil contains ≤2% C22:1, and in Europe contains ≤25 μmol/g seed GSL. Furthermore, Canola type rapeseed contains only about 7% saturated fatty acids (palmitic, C16:0+stearic, C18:0) while having about 60% oleic acid (C18:1), 20% linoleic acid (C18:2), and 10% linolenic acid (C18:3). Nowadays, different types of rapeseeds with a modified fatty acid composition are available for different purposes (Table 1.1).

Table 1.1 Fatty acid composition of different rapeseed quality types in % of total fatty acids (Möllers, 2002b)

Oil quality (fatty acids)	Saturated*	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Erucic C22:1
'00' Canola	7	60	20	10	<2
High Erucic (HEAR)	6	15	13	9	58**
Low Linolenic (LL)	7	60	30	2	<2
High Oleic (HOAR)	5	86	4	4	<2
High Oleic/Low Linolenic (HOLL)	5	85	6	2	<2

* mainly C16:0 (3-4%) and C18:0 (1-2%)
** includes ≈8% C20:1

Apart from their nutritional value, reduction of polyunsaturated fatty acids are important from technical point of view. Oil containing a low content of polyunsaturated fatty acids (C18:2 and C18:3) is more stable at high temperature without smoking, and it is less prone to oxidative changes during refining, storage and frying (Miller et al., 1987, Scarth et al., 1988, Lopez et al., 2000). The first attempt to increase the oil stability was started by developing 'Stellar', a Canadian spring rape cultivar following the success of mutagenesis of the 'Oro' cultivar (Röbbelen and Nitsch, 1975), to produce 'Low Linolenic' (LL, see Table 1.1) type rapeseed.

Tailoring oleic acid content to more than 80% and lowering C18:2 and C18:3 to around 10% for the sum of these fatty acids has been achieved through mutation breeding and gene technology. These types are classified as high oleic acid rapeseed or high oleic/low linolenic rapeseed (HOLL) (Auld et al. 1992, Rücker and Röbbelen, 1995, Stoutjesdijk et. al., 1999, Schierholt and Becker, 2001).

Development of rapeseed containing high erucic acid is also of interest for plant breeders, since this component and its derivatives are important raw material for industrial applications (Piazza and Foglia, 2001). This fatty acid is