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(54) Titre : GENES POUR DESATURASES D'ACIDE GRAS DELTA-12 MICROSOMAUx MUTANTS ET ENZYMES
PERTINENTS DE PLANTES

(54) Title: GENES FOR MUTANT MICROSOMAL DELTA-12 FATTY ACID DESATURASES AND RELATED ENZYMES
FROM PLANTS

(57) Abrégé/Abstract:

The preparation and use of nucleic acid fragments encoding fatty acid desaturase enzymes are described. The invention permits alteration of plant lipid composition. Chimeric genes incorporating such nucleic acid fragments with suitable regulatory sequences may be used to create transgenic plants with altered levels of unsaturated fatty acids.

GENES FOR MICROSOMAL DELTA-12 FATTY ACID
DESATURASES AND RELATED ENZYMES FROM PLANTS
ABSTRACT OF THE DISCLOSURE

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TITLE
GENES FOR MUTANT MICROSOMAL DELTA-12 FATTY ACID
DESATURASES AND RELATED ENZYMES FROM PLANTS

FIELD OF THE INVENTION

5 The invention relates to the preparation and use of
nucleic acid fragments encoding fatty acid desaturase
enzymes to modify plant lipid composition. Chimeric genes
incorporating such nucleic acid fragments and suitable
regulatory sequences may be used to create transgenic
10 plants with altered levels of unsaturated fatty acids.

BACKGROUND OF THE INVENTION

Plant lipids have a variety of industrial and
nutritional uses and are central to plant membrane function
and climatic adaptation. These lipids represent a vast
15 array of chemical structures, and these structures
determine the physiological and industrial properties of
the lipid. Many of these structures result either directly
or indirectly from metabolic processes that alter the
degree of unsaturation of the lipid. Different metabolic
20 regimes in different plants produce these altered lipids,
and either domestication of exotic plant species or
modification of agronomically adapted species is usually
required to economically produce large amounts of the
desired lipid.

25 Plant lipids find their major use as edible oils in the
form of triacylglycerols. The specific performance and
health attributes of edible oils are determined largely by
their fatty acid composition. Most vegetable oils derived
from commercial plant varieties are composed primarily of
30 palmitic (16:0), stearic (18:0), oleic (18:1), linoleic
(18:2) and linolenic (18:3) acids. Palmitic and stearic
acids are, respectively, 16- and 18-carbon-long, saturated
fatty acids. Oleic, linoleic, and linolenic acids are 18-
carbon-long, unsaturated fatty acids containing one, two,
35 and three double bonds, respectively. Oleic acid is
referred to as a mono-unsaturated fatty acid, while
linoleic and linolenic acids are referred to as poly-
unsaturated fatty acids.

Many recent research efforts have examined the role that saturated and unsaturated fatty acids play in reducing the risk of coronary heart disease. In the past, it was believed that mono-unsaturates, in contrast to saturates and poly-unsaturates, had no effect on serum cholesterol and coronary heart disease risk. Several recent human clinical studies suggest that diets high in mono-unsaturated fat and low in saturated fat may reduce the "bad" (low-density lipoprotein) cholesterol while maintaining the "good" (high-density lipoprotein) cholesterol (Mattson et al., *Journal of Lipid Research* (1985) 26:194-202).

A vegetable oil low in total saturates and high in mono-unsaturates would provide significant health benefits to consumers as well as economic benefits to oil processors. For specialized uses, high levels of poly-unsaturates can be desirable. Linoleate and linolenate are essential fatty acids in human diets, and an edible oil high in these fatty acids can be used for nutritional supplements, for example in baby foods.

The biosynthesis of the major plant lipids has been the focus of much research (Browse et al., *Ann. Rev. Plant Physiol. Mol. Biol.* (1991) 42:467-506). These studies show that, with the notable exception of the soluble stearyl-acyl carrier protein desaturase, the controlling steps in the production of unsaturated fatty acids are largely catalyzed by membrane-associated fatty acid desaturases. Desaturation reactions occur in plastids and in the endoplasmic reticulum using a variety of substrates including galactolipids, sulfolipids, and phospholipids. Genetic and physiological analyses of *Arabidopsis thaliana* nuclear mutants defective in various fatty acid desaturation reactions indicates that most of these reactions are catalyzed by enzymes encoded at single genetic loci in the plant. These investigations have demonstrated the role of delta-12 desaturase and delta-15 desaturase activities in the production of linoleate and linolenate from 2-oleoyl-phosphatidylcholine and

2-linoleoyl-phosphatidylcholine, respectively (Wang et al.,
Plant Physiol. Biochem. (1988) 26:777-792). Thus,
modification of the activities of these enzymes represents
an attractive target for altering the levels of lipid
unsaturation by genetic engineering.

The cloning and characterization of wild-type delta-12
fatty acid desaturases has been reported (Okuley, et al.,
Plant Cell (1994) 6:147-158). However, there are no
teachings concerning plants having seed-specific expression
of mutant delta-12 or delta-15 fatty acid desaturase gene
products. Furthermore, no methods have been described for
altering the fatty acid composition of plants using nucleic
acid constructs expressing a mutant delta-12 or a mutant
delta-15 fatty acid desaturase.

SUMMARY OF THE INVENTION

Applicants have discovered a means to control the
nature and levels of unsaturated fatty acids in plants.
Nucleic acid fragments from cDNAs or genes encoding mutant
fatty acid desaturases are used to create chimeric genes.
The chimeric genes may be used to transform various plants
to modify the fatty acid composition of the plant or the
oil produced by the plant. The invention comprises nucleic
acid constructs containing mutant microsomal delta-12 or
mutant microsomal delta-15 fatty acid desaturase coding
sequences, which are operably linked in sense orientation
to at least one regulatory sequence. Such a construct is
effective for altering fatty acid composition of seeds when
the construct is introduced into a plant. In one
embodiment, a mutant coding sequence for a delta-12 fatty
acid desaturase comprises the mutation in the sequence of
SEQ ID NO:3.

The invention further comprises seeds, plants and plant
lines having a recombinant nucleic acid construct
containing at least one regulatory sequence linked in sense
orientation to a mutant delta-12 or mutant delta-15 fatty
acid desaturase. The mutant chimeric gene preferentially
is expressed in seeds and results in an altered fatty acid
composition in seeds of such plants. A plant expressing a

mutant delta-12 desaturase gene preferably has a reduced level of linoleic acid in seeds. A plant expressing a mutant delta-15 desaturase gene preferably has a reduced level of α -linolenic acid in seeds. If desired, a plant of the invention may express both a mutant delta-12 and a mutant delta-15 fatty acid desaturase, resulting in the reduction of both linoleic acid and α -linolenic acid in seeds.

Yet another embodiment of the invention involves a method of producing seed oil containing altered levels of unsaturated fatty acids comprising: (a) transforming a plant cell with a chimeric gene described above; (b) growing sexually mature plants from the transformed plant cells of step (a); (c) screening progeny seeds from the sexually mature plants of step (b) for the desired levels of unsaturated fatty acids, and (d) processing the progeny seed of step (c) to obtain seed oil containing altered levels of the unsaturated fatty acids. Preferred plant cells and oils are derived from soybean, rapeseed, sunflower, cotton, cocoa, peanut, safflower, coconut, flax, oil palm, and corn. Preferred methods of transforming such plant cells would include the use of Ti and Ri plasmids of Agrobacterium, electroporation, and high-velocity ballistic bombardment.

Yet another aspect of the invention involves a method of producing seeds having altered fatty acid composition. The method comprises the step of introducing a recombinant nucleic acid construct into a plant (i.e., transforming a plant). The construct comprises one or more seed-specific regulatory sequences operably linked in sense orientation to a mutant delta-12 fatty acid desaturase gene or a mutant delta-15 fatty acid desaturase gene. After obtaining transgenic progeny, those transformed plants that produce seeds having an altered fatty acid composition are identified. Suitable plants for transformation include, for example, soybean, rapeseed, sunflower, safflower, castor bean and corn. Suitable methods of transforming

such plants include, for example, Agrobacterium-mediated methods, electroporation, and microprojectile bombardment.

The invention also is embodied in a method of RFLP breeding to obtain altered levels of oleic acids in the seed oil of oil producing plant species. This method involves (a) making a cross between two varieties of oil producing plant species differing in the oleic acid trait; (b) making a Southern blot of restriction enzyme digested genomic DNA isolated from several progeny plants resulting from the cross; and (C) hybridizing the Southern blot with the radiolabelled nucleic acid fragments encoding the mutant fatty acid desaturases or desaturase-related enzymes.

The invention is also embodied in a method of RFLP mapping that uses the isolated mutant microsomal delta-12 desaturase cDNA or related genomic fragments described herein.

Another embodiment of the instant invention is a method of genotyping plants containing either a mutant or wild-type form of the delta-12 desaturase gene by PCR amplification of genomic DNA using gene-specific primers. This method is capable of discriminating genes that differ by only one or a few nucleotides, thus affording a means for detecting plants containing the mutant delta-12 desaturase.

Another aspect of the invention comprises vegetable oil extracted from seeds of plants disclosed herein. Such a vegetable oil contains an altered fatty acid composition, e.g., a decreased level of α -linolenic acid, a decreased level of linoleic acid, or an increased level of oleic acid, based on total fatty acid composition.

5a

In accordance with an aspect of the present invention there is provided a method for altering fatty acid composition in plant seeds, comprising the steps of:

5 a) introducing a recombinant nucleic acid construct into a plant, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Glu located in a His-Glu-Cys-Gly-His motif wherein said at least one mutation results in a dominant negative suppression of endogenous

10 fatty acid desaturase activity in said plant; and b) obtaining progeny from said plant, said progeny producing said seeds having an oleic acid content of from about 69% to about 90%.

In accordance with a further aspect of the present invention there is

15 provided a method of making a vegetable oil, comprising extracting said oil from seeds of one or more plants, said plants having a recombinant nucleic acid construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one

20 mutation of a substitution of Lys for Glu located in a His-Glu-Cys-Gly-His motif, wherein said oil has an oleic acid content of from about 69% to about 90%.

In accordance with a further aspect of the present invention there is provided a recombinant nucleic acid construct effective for increasing oleic acid

25 content when expressed in seeds, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one mutation which renders said desaturase protein nonfunctional, said mutation being a substitution of Lys for Glu in a His-

30 Glu-Cys-Y-His (SEQ ID NO: 17) amino acid motif, wherein Y is selected from the group consisting of Gly and Ala.

In accordance with a further aspect of the present invention, there is provided a method for altering fatty acid composition in plant seeds, comprising

35 the steps of: a) introducing a recombinant nucleic acid construct into a plant, said construct comprising at least one seed-specific regulatory sequence operably

5b

linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Asp located in a His-Asp-Cys-Gly-His motif
5 wherein said at least one mutation results in a dominant negative suppression of endogenous fatty acid desaturase activity in said plant; and b) obtaining progeny from said plant, said progeny producing said seeds having an oleic acid content of from about 69% to about 90%.

10 In accordance with a further aspect of the present invention, there is provided a method of making a vegetable oil, comprising extracting said oil from seeds of one or more plants, said plants having a recombinant nucleic acid construct comprising at least one seed-specific regulatory sequence operably
15 linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Asp located in a His-Asp-Cys-Gly-His motif, wherein said oil has an oleic acid content of from about 69% to about 90%.

In accordance with a further aspect of the present invention, there is
20 provided a recombinant nucleic acid construct effective for increasing oleic acid content when expressed in seeds, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation which renders said desaturase
25 protein nonfunctional, said mutation being a substitution of Lys for Asp in a His-Asp-Cys-Y-His (SEQ ID NO: 17) amino acid motif, wherein Y is selected from the group consisting of Gly and Ala.

BRIEF DESCRIPTION OF THE SEQUENCE DESCRIPTIONS

30 The invention can be more fully understood from the following detailed description and the Sequence Descriptions which form a part of this application.

The Sequence Descriptions contain the standard three letter codes for amino acids.

SEQ ID NO:1 shows the 5' to 3' nucleotide sequence of 1464 base pairs of the Brassica napus cDNA which encodes the wild type D form of microsomal delta-12 desaturase in plasmid pCF2-165d.

5 SEQ ID NO:2 is the 384 amino acid protein sequence deduced from the open reading frame in SEQ ID NO:1.

10 SEQ ID NO:3 shows the 5' to 3' cDNA nucleotide sequence of a mutant D form of microsomal delta-12 fatty acid desaturase from Brassica napus IMC129. Nucleotides 1-3 are the initiation codon and nucleotides 1153-1155 are the termination codon.

SEQ ID NO:4 is the 384 amino acid protein sequence deduced from the open reading frame of SEQ ID NO:3.

15 SEQ ID NO:5 shows the 5' to 3' cDNA nucleotide sequence of the wild-type F form of microsomal delta-12 fatty acid desaturase in Brassica napus. Nucleotides 1-3 are the initiation codon and nucleotides 1153-1155 are the termination codon.

20 SEQ ID NO:6 is the 384 amino acid protein sequence deduced from the open reading frame of SEQ ID NO:5.

25 SEQ ID NO:7 shows the 5' to 3' cDNA nucleotide sequence of a mutant F form of microsomal delta-12 fatty acid desaturase from Brassica napus IMC Q508. Nucleotides 1-3 are the initiation codon and nucleotides 1153-1155 are the termination codon.

SEQ ID NO:8 is the 384 amino acid protein sequence deduced from the open reading frame of SEQ ID NO:7.

30 SEQ ID NO:9 is the upstream (5') primer used for isolation of the D form of microsomal delta-12 fatty acid desaturase gene from Brassica napus.

SEQ ID NO:10 is the downstream (3') primer used for isolation of the D form of microsomal delta-12 fatty acid desaturase gene from Brassica napus.

35 SEQ ID NO:11 is the upstream (5') primer used for isolation of the F form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

SEQ ID NO:12 is the downstream (3') primer used for isolation of the F form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

5 SEQ ID NO:13 is the upstream (5') primer used for gene-specific detection of the wild type D form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

SEQ ID NO:14 is the upstream (5') primer used for gene-specific detection of the mutant D form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

10 SEQ ID NO:15 is the modified upstream (5') primer used for gene-specific detection of the wild type D form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

15 SEQ ID NO:16 is the modified upstream (5') primer used for gene-specific detection of the mutant D form of microsomal delta-12 fatty acid desaturase gene in Brassica napus.

BRIEF DESCRIPTION OF THE FIGURES

20 Figure 1 is a schematic drawing of plasmid pZPhMcFd2, showing restriction sites and relative position and orientation of the bean phaseolin promoter (5' Phas), the IMC129 mutant microsomal delta-12 fatty acid desaturase D form coding sequence (MCFd2) and the bean phaseolin 3' untranslated region (3' Phas).

25 Figure 2 is a schematic drawing of plasmid pIMC127, showing restriction sites and the relative positions and orientation of the napin promoter (5' nap), the wild-type microsomal delta-12 fatty acid desaturase D form coding sequence (CanFd2) and the napin 3' untranslated region (3' Nap).

30 Figure 3 shows the frequency distribution of seed oil linoleic acid (C18:2) content in transgenic Brassica T2 populations transformed with either a napin promoter linked in sense orientation to a wild-type microsomal delta-12 fatty acid desaturase D form coding sequence (WS127) or a phaseolin promoter linked to a mutant delta-12 fatty acid desaturase D form (WS201).

Figure 4 shows the frequency distribution of seed oil linoleic acid content in transgenic Brassica T2 populations transformed with either a napin promoter linked in sense orientation to a mutant F form (WS140) delta-12 fatty acid desaturase coding sequence or a cruciferin promoter linked to a wild-type delta-12 fatty acid desaturase D form (WS135).

DETAILED DESCRIPTION OF THE INVENTION

Nucleic acid fragments have been isolated that encode mutant plant fatty acid desaturases and that are useful in modifying fatty acid composition in oil-producing species by genetic transformation.

Transfer of the nucleic acid fragments of the invention or a part thereof, along with suitable regulatory sequences that direct the transcription of their mRNA, into plants may result in production of decreased levels of unsaturated fatty acids in cellular lipids, including triacylglycerols.

The nucleic acid fragments of the invention can also be used as DNA diagnostic markers in plant genetic mapping and plant breeding programs.

The nucleic acid fragments of the invention or oligomers derived therefrom can also be used to isolate other related fatty acid desaturase genes using DNA, RNA, or a library of cloned nucleotide sequences from the same or different species by well known sequence-dependent protocols, including, for example, methods of nucleic acid hybridization and amplification by the polymerase chain reaction.

Definitions

In the context of this disclosure, a number of terms shall be used. Fatty acids are specified by the number of carbon atoms and the number and position of the double bond: the numbers before and after the colon refer to the chain length and the number of double bonds, respectively. The number following the fatty acid designation indicates the position of the double bond from the carboxyl end of the fatty acid with the "c" affix for the cis-configuration of the double bond. For example, palmitic acid (16:0),

stearic acid (18:0), oleic acid (18:1,9c), petroselinic acid (18:1, 6c), linoleic acid (18:2,9c,12c), γ -linolenic acid (18:3, 6c,9c,12c) and α -linolenic acid (18:3, 9c,12c,15c). Unless otherwise specified 18:1, 18:2 and 18:3 refer to oleic, linoleic and linolenic fatty acids. The term "fatty acid desaturase" used herein refers to an enzyme which catalyzes the breakage of a carbon-hydrogen bond and the introduction of a carbon-carbon double bond into a fatty acid molecule. The fatty acid may be free or esterified to another molecule including, but not limited to, acyl-carrier protein, coenzyme A, sterols and the glycerol moiety of glycerolipids. The term "glycerolipid desaturases" used herein refers to a subset of the fatty acid desaturases that act on fatty acyl moieties esterified to a glycerol backbone. "Delta-12 desaturase" refers to a fatty acid desaturase that catalyzes the formation of a double bond between carbon positions 6 and 7 (numbered from the methyl end), (i.e., those that correspond to carbon positions 12 and 13 (numbered from the carbonyl carbon) of an 18 carbon-long fatty acyl chain. "Delta-15 desaturase" refers to a fatty acid desaturase that catalyzes the formation of a double bond between carbon positions 3 and 4 (numbered from the methyl end), (i.e., those that correspond to carbon positions 15 and 16 (numbered from the carbonyl carbon) of an 18 carbon-long fatty acyl chain. Examples of fatty acid desaturases include, but are not limited to, the microsomal delta-12 and delta-15 desaturases that act on phosphatidylcholine lipid substrates; the chloroplastic or plastid delta-12 and delta-15 desaturases that act on phosphatidyl glycerol and galactolipids; and other desaturases that act on such fatty acid substrates such as phospholipids, galactolipids, and sulfolipids. "Microsomal desaturase" refers to the cytoplasmic location of the enzyme, while "chloroplast desaturase" and "plastid desaturase" refer to the plastid location of the enzyme. These fatty acid desaturases may be found in a variety of organisms including, but not limited to, higher plants, diatoms, and various eukaryotic

and prokaryotic microorganisms such as fungi and photosynthetic bacteria and algae. The term "homologous fatty acid desaturases" refers to fatty acid desaturases that catalyze the same desaturation on the same lipid substrate. Thus, microsomal delta-15 desaturases, even from different plant species, are homologous fatty acid desaturases. The term "heterologous fatty acid desaturases" refers to fatty acid desaturases that catalyze desaturations at different positions and/or on different lipid substrates. Thus, for example, microsomal delta-12 and delta-15 desaturases, which act on phosphatidylcholine lipids, are heterologous fatty acid desaturases, even when from the same plant. Similarly, microsomal delta-15 desaturase, which acts on phosphatidylcholine lipids, and chloroplast delta-15 desaturase, which acts on galactolipids, are heterologous fatty acid desaturases, even when from the same plant. It should be noted that these fatty acid desaturases have never been isolated and characterized as proteins. Accordingly, the terms such as "delta-12 desaturase" and "delta-15 desaturase" are used as a convenience to describe the proteins encoded by nucleic acid fragments that have been isolated based on the phenotypic effects caused by their disruption. They do not imply any catalytic mechanism. For example, delta-12 desaturase refers to the enzyme that catalyzes the formation of a double bond between carbons 12 and 13 of an 18 carbon fatty acid irrespective of whether it "counts" the carbons from the methyl, carboxyl end, or the first double bond.

The term "nucleic acid" refers to a large molecule which can be single-stranded or double-stranded, composed of monomers (nucleotides) containing a sugar, a phosphate and either a purine or pyrimidine. A "nucleic acid fragment" is a fraction of a given nucleic acid molecule. In higher plants, deoxyribonucleic acid (DNA) is the genetic material while ribonucleic acid (RNA) is involved in the transfer of the information in DNA into proteins. A "genome" is the entire body of genetic material contained

in each cell of an organism. The term "nucleotide sequence" refers to the sequence of DNA or RNA polymers, which can be single- or double-stranded, optionally containing synthetic, non-natural or altered nucleotide bases capable of incorporation into DNA or RNA polymers. The term "oligomer" refers to short nucleotide sequences, usually up to 100 bases long.

From time to time, the term "FAD2" may be used herein as a shorthand notation for a nucleotide sequence encoding a wild type microsomal delta-12 fatty acid desaturase enzyme, and the term "fad2" may be used herein as a shorthand notation for a nucleotide sequence encoding a mutant form of a microsomal delta-12 fatty acid desaturase enzyme.

As used herein, the term "homologous to" refers to the relatedness between the nucleotide sequence of two nucleic acid molecules or between the amino acid sequences of two protein molecules. Estimates of such homology are provided by either DNA-DNA or DNA-RNA hybridization under conditions of stringency as is well understood by those skilled in the art (Hames and Higgins, Eds. (1985) Nucleic Acid Hybridisation, IRL Press, Oxford, U.K.); or by the comparison of sequence similarity between two nucleic acids or proteins, such as by the method of Needleman et al. (J. Mol. Biol. (1970) 48:443 453). As used herein, "essentially similar" refers to DNA sequences that may involve base changes that do not cause a change in the encoded amino acid, or which involve base changes which may alter one or more amino acids, but do not affect the functional properties of the protein encoded by the DNA sequence. It is therefore understood that the invention encompasses more than the specific exemplary sequences. Modifications to the sequence, such as deletions, insertions, or substitutions in the sequence which produce silent changes that do not substantially affect the functional properties of the resulting protein molecule are also contemplated. For example, alteration in the gene sequence which reflect the degeneracy of the genetic code,

or which results in the production of a chemically equivalent amino acid at a given site, are contemplated; thus, a codon for the amino acid alanine, a hydrophobic amino acid, may be substituted by a codon encoding another hydrophobic amino acid residue such as glycine, valine, leucine, or isoleucine. Similarly, changes which result in substitution of one negatively charged residue for another, such as aspartic acid for glutamic acid, or one positively charged residue for another, such as lysine for arginine, can also be expected to produce a biologically equivalent product. Nucleotide changes which result in alteration of the N-terminal and C-terminal portions of the protein molecule would also not be expected to alter the activity of the protein. Each of the proposed modifications is well within the routine skill in the art, as is determination of retention of biological activity of the encoded products.

"Gene" refers to a nucleic acid fragment that encodes a specific protein, including regulatory sequences preceding (5' non-coding) and following (3' non-coding) the coding region. "Fatty acid desaturase gene" refers to a nucleic acid fragment that encodes a protein with fatty acid desaturase activity. "Native" gene refers to an isolated gene with its own regulatory sequences as found in nature. "Chimeric gene" refers to a gene that comprises heterogeneous regulatory and coding sequences not found in nature. "Endogenous" gene refers to the native gene normally found in its natural location in the genome and is not isolated. A "foreign" gene refers to a gene not normally found in the host organism but that is introduced by gene transfer. "Pseudo-gene" refers to a genomic nucleotide sequence that does not encode a functional enzyme. "Mutant gene" refers to a gene comprising one or more nucleotides that have been altered when compared to the wild-type nucleotide sequence, resulting in a change to the amino acid sequence and functional properties of the encoded protein. Thus, a "mutation" is a change which occurs in a gene to give rise to an altered form of the gene which differs from the wild-type gene. As those

skilled in the art will appreciate such changes can occur due to a deletion, addition, substitution or combination thereof.

"Coding sequence" refers to a DNA sequence that codes for a specific protein and excludes the non-coding sequences. It may constitute an "uninterrupted coding sequence", i.e., lacking an intron or it may include one or more introns bounded by appropriate splice junctions. An "intron" is a nucleotide sequence that is transcribed into a primary transcript but that is removed through cleavage and re-ligation of the RNA within the cell to create a mature mRNA that can be translated into a protein.

"Initiation codon" and "termination codon" refer to a unit of three adjacent nucleotides in a coding sequence that specifies initiation and chain termination, respectively, of protein synthesis (mRNA translation).

"Open reading frame" refers to the coding sequence uninterrupted by introns between initiation and termination codons that encodes an amino acid sequence.

"RNA transcript" refers to the product resulting from RNA polymerase-catalyzed transcription of a DNA sequence. When the RNA transcript is a perfect complementary copy of the DNA sequence, it is referred to as the primary transcript or it may be a RNA sequence derived from posttranscriptional processing of the primary transcript and is referred to as the mature RNA. "Messenger RNA (mRNA)" refers to the RNA that is without introns and that can be translated into protein by the cell. "cDNA" refers to a double-stranded DNA that is complementary to and derived from mRNA. "Sense" RNA refers to RNA transcript that includes the mRNA. "Antisense RNA" refers to a RNA transcript that is complementary to all or part of a target primary transcript or mRNA and may block the expression of a target gene by interfering with the processing, transport and/or translation of its primary transcript or mRNA. The complementarity of an antisense RNA may be with any part of the specific gene transcript, i.e., at the 5' non-coding sequence, 3' non-coding sequence, introns, or the coding

sequence. In addition, as used herein, antisense RNA may contain regions of ribozyme sequences that increase the efficacy of antisense RNA to block gene expression.

"Ribozyme" refers to a catalytic RNA and includes sequence-specific endoribonucleases.

As used herein, "suitable regulatory sequences" refer to nucleotide sequences in native or chimeric genes that are located upstream (5'), within, and/or downstream (3') to the nucleic acid fragments of the invention, which control the expression of the nucleic acid fragments of the invention. The term "expression", as used herein, refers to the transcription and stable accumulation of the sense (mRNA) derived from the nucleic acid fragment(s) of the invention that, in conjunction with the protein apparatus of the cell, results in altered levels of the fatty acid desaturase(s). Expression or overexpression of the gene involves transcription of the gene and translation of the mRNA into precursor or mature fatty acid desaturase proteins. "Altered levels" refers to the production of gene product(s) in transgenic organisms in amounts or proportions that differ from that of normal or non-transformed organisms.

"Promoter" refers to a DNA sequence in a gene, usually upstream (5') to its coding sequence, which controls the expression of the coding sequence by providing the recognition for RNA polymerase and other factors required for proper transcription. Promoters may also contain DNA sequences that are involved in the binding of protein factors which control the effectiveness of transcription initiation in response to physiological or developmental conditions. It may also contain enhancer elements. An "enhancer" is a DNA sequence which can stimulate promoter activity. It may be an innate element of the promoter or a heterologous element inserted to enhance the level and/or tissue-specificity of a promoter. "Constitutive promoters" refers to those that direct gene expression in all tissues and at all times. "Tissue-specific" or "development-specific" promoters as referred to herein are those that

direct gene expression almost exclusively in specific tissues, such as leaves or seeds, or at specific development stages in a tissue, such as in early or late embryogenesis, respectively.

5 The "3' non-coding sequences" refers to the DNA sequence portion of a gene that contains a polyadenylation signal and any other regulatory signal capable of affecting mRNA processing or gene expression. The polyadenylation signal is usually characterized by affecting the addition
10 of polyadenylic acid tracts to the 3' end of the mRNA precursor.

 "Transformation" herein refers to the transfer of a foreign gene into the genome of a host organism and its genetically stable inheritance. "Restriction fragment
15 length polymorphism" (RFLP) refers to different sized restriction fragment lengths due to altered nucleotide sequences in or around variant forms of genes. "Molecular breeding" refers to the use of DNA-based diagnostics, such as RFLP, RAPDs, and PCR in breeding. "Fertile" refers to
20 plants that are able to propagate sexually.

 "Plants" refer to photosynthetic organisms, both eukaryotic and prokaryotic, whereas the term "Higher plants" refers to eukaryotic plants. "Oil-producing species" herein refers to plant species which produce and
25 store triacylglycerol in specific organs, primarily in seeds. Such species include soybean (Glycine max), rapeseed and canola (including Brassica napus, B. campestris), sunflower (Helianthus annus), cotton (Gossypium hirsutum), corn (Zea mays), cocoa (Theobroma cacao),
30 safflower (Carthamus tinctorius), oil palm (Elaeis guineensis), coconut palm (Cocos nucifera), flax (Linum usitatissimum), (castor (Ricinus communis)) and peanut (Arachis hypogaea). The group also includes non-agronomic species which are useful in developing appropriate
35 expression vectors such as tobacco, rapid cycling Brassica species, and Arabidopsis thaliana, and wild species which may be a source of unique fatty acids.

"Progeny" includes descendants of a particular plant or plant line, e.g., seeds and plants of F1, F2, F3, and subsequent generations, or seeds and plants of backcrossed populations BC1, BC2, BC3 and subsequent generations.

5 "Sequence-dependent protocols" refer to techniques that rely on a nucleotide sequence for their utility. Examples of sequence-dependent protocols include, but are not limited to, the methods of nucleic acid and oligomer hybridization and methods of DNA and RNA amplification such as are exemplified
10 in various uses of the polymerase chain reaction (PCR).

Various solutions used in the experimental manipulations are referred to by their common names such as "SSC", "SSPE", "Denhardt's solution", etc. The composition of these solutions may be found by reference to Appendix B of Sambrook, et al.
15 (Molecular Cloning, A Laboratory Manual, 2nd ed. (1989), Cold Spring Harbor Laboratory Press).

AVAILABILITY AND RELATEDNESS OF WILD-TYPE MICROSOMAL

DELTA-12 AND DELTA-15 FATTY ACID DESATURASES

WO 94/11516 describes the isolation and characterization
20 of cDNAs encoding wild-type microsomal delta-12 fatty acid desaturases from a number of plant species, including *Arabidopsis thaliana*, *Brassica napus*, *Glycine max*, *Zea mays* and Castor bean. Moreover, that application demonstrates successful alteration of fatty acid content of oils from seeds
25 obtained from transgenic plants expressing sense or antisense mRNAs encoding microsomal delta-12 fatty acid desaturases.

Alignments of protein sequences of plant microsomal fatty acid delta-12 desaturases and plant delta-15 desaturases [microsomal and plastid delta-15 desaturases from *Arabidopsis*
30 and *Brassica napus*, WO 9311245] allows identification of amino acid sequences conserved between the different desaturases (Table 1)

TABLE 1
Amino Acid Sequences Conserved Between
Plant Microsomal Delta-12 Desaturases and Microsomal and
Plastid Delta-15 Desaturases

Region	Conserved AA Positions in SEQ ID NO:2 of USSN 08/262,401	Consensus Conserved AA Sequence in Δ^{12} Desaturases	Consensus Conserved AA Sequence in Δ^{15} Desaturases	Consensus AA Sequence
A	39-44	AIPPHC	AIPKHC	AIP(P/K)HC
B	86-90	WP(L/I)YW	WPLYW	WP(L/I)YW
C	104-109	AHECGH	GHDCGH	(A/G)H(D/E)CGH
D	130-134	LLVPY	ILVPY	(L/I)LVPY
E	137-142	WKYSHR	WRISHR	W(K/R)(Y/I)SHR
F	140-145	SHRRHH	SHRTHH	SHR(R/T)HH
G	269-274	ITYLQ	VTYLH	(I/V)TYL(Q/H)
H	279-282	LPHY	LPWY	LP(H/W)Y
I	289-294	WL(R/K)GAL	YLRGGL	(W/Y)L(R/K)G(A/G)L
J	296-302	TVDRDYG	TLDRDYG	T(V/L)DRDYG
K	314-321	THVAHHLF	THVIHHLF	THV(A/I)HHLF
L	318-327	HHLFSTMPHY	HHLFPQIPHY	HHLF(S/P) (T/Q)(I/M)PHY

Table 1 shows twelve regions of conserved amino acid sequences, designated A-L (column 1), whose positions in SEQ ID NO:2 of US patent 6372965 issued Apr 6/02 are shown in column 2. The consensus sequences for these regions in plant delta-12 fatty acid desaturases and plant delta-15 fatty acid desaturases are shown in columns 3 and 4, respectively; amino acids are shown by standard abbreviations, the underlined amino acids are conserved between the delta-12 and the delta-15 desaturases, and amino acids in brackets represent substitutions found at that position. The consensus sequence of these regions are shown in column 5. These short conserved amino acids and their relative positions further confirm that the isolated isolated cDNAs encode a fatty acid desaturase.

INHIBITION OF PLANT TARGET GENES
BY DOMINANT NEGATIVE SUPPRESSION

In one embodiment, transgenic plants according to the invention contain an introduced nucleic acid construct that comprises at least a portion of a mutant delta-12 or

delta-15 desaturase coding sequence. Surprisingly, a construct comprising a mutant delta-12 desaturase or delta-15 desaturase coding sequence, operably linked in sense orientation to one or more regulatory sequences, has
5 been found to inhibit the corresponding endogenous fatty acid desaturase activity in plants which contain such a construct. This phenomenon has been termed dominant negative suppression.

The basis for the phenomenon of dominant negative suppression is not understood. One possible explanation is
10 that the delta-12 desaturase gene product exists as a dimer in vivo. If so, a dimer consisting of the mutant gene product and the wild-type gene product may be non-functional. Regardless of the actual mechanism by which
15 dominant negative suppression operates, the observation that transformation of plants with a mutant delta-12 desaturase gene results in a large proportion of the transgenic progeny having endogenous wild-type enzyme activity inhibited by expression of the mutant gene can be
20 used to advantage. For example, the phenomenon of dominant negative suppression can be used to alter plant desaturase enzyme activity in a tissue-specific manner. The phenomenon may also allow transformation experiments to be carried out in which a higher proportion of the resulting
25 transgenic plants have a desired altered fatty acid profile and allow transgenic plants having desired fatty acid profiles to be more readily obtained.

Preferred constructs contain, in addition, at least one regulatory sequence operably linked in the sense
30 orientation to the mutant coding sequence. Regulatory sequences typically do not themselves code for a gene product. Instead, regulatory sequences affect the expression level of the mutant coding sequence.

In preferred embodiments, regulatory sequences for
35 dominant negative suppression are tissue-specific, i.e., the mutant desaturase gene product is preferentially expressed in certain plant tissues and expressed at low levels or not at all in the remaining tissues of the plant.

Suitable tissue-specific regulatory sequences include those that permit expression preferentially in developing seeds. Seed-specific regulatory sequences preferably stimulate or induce levels of mutant desaturase gene product expression that coincide with the levels of wild-type desaturase gene product expression.

Dominant negative suppression plants according to the invention preferably yield seeds containing an altered fatty acid profile. For example, oil obtained from seeds of such plants may have from about 69% to about 90% oleic acid, based on the total fatty acid composition of the seed. Such oil preferably has from about 74% to about 90% oleic acid, more preferably from about 80% to about 90% oleic acid. In some embodiments, oil extracted from seeds produced by plants of the invention may have from about 3% to about 5% saturated fatty acids, based on total fatty acid composition of the seeds. In some embodiments, oil extracted from seeds of the invention may have from about 1% to about 10% linoleic acid, or from about 1% to about 10% α -linolenic acid.

After a recombinant nucleic acid construct, comprising a mutant microsomal delta-12 fatty acid desaturase coding sequence operably linked in the sense orientation to one or more regulatory sequences, is introduced into a plant, seeds of transgenic plants are grown and either selfed or outcrossed. Progeny are analyzed to identify those individuals having endogenous wild-type delta-12 fatty acid desaturase activity inhibited by dominant negative suppression as discussed above.

Method similar to those described above are used to make delta-15 desaturase dominant negative suppression constructs, comprising a mutant delta-15 desaturase gene operably linked to at least one regulatory sequence. Transformation of a plant with such a construct will result in dominant negative suppression of endogenous delta-15 desaturase activity in transgenic progeny and in a decreased level of α -linolenic acid in homozygous dominant suppression lines. Such lines will have from about <1% to

about 10% α -linolenic acid, preferably from about <1% to about 5%, based on total seed fatty acid composition.

In one embodiment of the invention, a plant contains a mutant delta-12 fatty acid desaturase and a mutant delta-15 fatty acid desaturase, both of which are expressed preferentially in seeds. Such a plant can be produced from the cross of single mutant plants, followed by outcrossing or selfing in order to obtain progeny seeds carrying both mutant chimeric genes. Progeny seeds are screened in order to identify those seeds carrying both mutant genes.

Alternatively, seed-specific defects in delta-12 desaturase and delta-15 desaturase may be introduced into a wild-type plant by transformation, simultaneously or sequentially, with one or more dominant negative suppression constructs for delta-12 desaturase and delta-15 desaturase, each driven by suitable regulatory sequences. Other similar methods to construct double mutant plants will be recognized by those of skill in the art.

Double mutant plants can have more extreme fatty acid profiles in seeds than the single mutant plants, e.g., the double mutant phenotype can result in significantly lower levels of α -linolenic acid in seeds than the single mutant delta-15 desaturase plant phenotype. Thus, by combining seed-specific inhibition of microsomal delta-12 desaturase with seed-specific inhibition of microsomal delta-15 desaturase, one can obtain levels of seed α -linolenic acid that are as low or lower than those in a single mutant without adversely affecting desirable properties. The decreased levels of α -linolenic acid in the double homozygotes may be associated with increased levels of oleic acid and decreased levels of saturates and linoleic acid.

SELECTION OF HOSTS, PROMOTERS AND ENHANCERS

A preferred class of heterologous hosts for the expression of the nucleic acid fragments of the invention are eukaryotic hosts, particularly the cells of higher plants. Particularly preferred among the higher plants are the oil-producing species, such as soybean (Glycine max),

rapeseed (including Brassica napus, B. campestris),
 sunflower (Helianthus annuus), cotton (Gossypium hirsutum),
 corn (Zea mays), cocoa (Theobroma cacao), safflower
 (Carthamus tinctorius), oil palm (Elaeis guineensis),
 5 coconut palm (Cocos nucifera), flax (Linum usitatissimum),
 and peanut (Arachis hypogaea).

Expression in plants will use regulatory sequences
 functional in such plants. The expression of foreign genes
 in plants is well-established (De Blaere et al., *Meth.*
 10 *Enzymol.* (1987) 153:277-291). The source of the promoter
 chosen to drive the expression of the fragments of the
 invention is not critical provided it has sufficient
 transcriptional activity to accomplish the invention by
 increasing or decreasing, respectively, the level of
 15 translatable mRNA for the fatty acid desaturases in the
 desired host tissue. Preferred promoters include
 (a) strong constitutive plant promoters, such as those
 directing the 19S and 35S transcripts in cauliflower mosaic
 virus (Odell et al., *Nature* (1985) 313:810-812; Hull et
 20 al., *Virology* (1987) 86:482-493), (b) tissue- or
 developmentally-specific promoters, and (c) other
 transcriptional promoter systems engineered in plants, such
 as those using bacteriophage T7 RNA polymerase promoter
 sequences to express foreign genes. Examples of tissue-
 25 specific promoters are the light-inducible promoter of the
 small subunit of ribulose 1,5-bis-phosphate carboxylase (if
 expression is desired in photosynthetic tissues), the maize
 zein protein promoter (Matzke et al., *EMBO J.* (1984)
 3:1525-1532), and the chlorophyll a/b binding protein
 30 promoter (Lampa et al., *Nature* (1986) 316:750-752).

Particularly preferred promoters are those that allow
 seed-specific expression. This may be especially useful
 since seeds are the primary source of vegetable oils and
 also since seed-specific expression will avoid any
 35 potential deleterious effect in non-seed tissues. Examples
 of seed-specific promoters include, but are not limited to,
 the promoters of seed storage proteins, which can represent
 up to 90% of total seed protein in many plants. The seed

storage proteins are strictly regulated, being expressed almost exclusively in seeds in a highly tissue-specific and stage-specific manner (Higgins et al., *Ann. Rev. Plant Physiol.* (1984) 35:191-221; Goldberg et al., *Cell* (1989) 56:149-160). Moreover, different seed storage proteins may be expressed at different stages of seed development.

Expression of seed-specific genes has been studied in great detail (See reviews by Goldberg et al., *Cell* (1989) 56:149-160 and Higgins et al., *Ann. Rev. Plant Physiol.* (1984) 35:191-221). There are currently numerous examples of seed-specific expression of seed storage protein genes in transgenic dicotyledonous plants. These include genes from dicotyledonous plants for bean β -phaseolin (Sengupta-Gopalan et al., *Proc. Natl. Acad. Sci. USA* (1985) 82:3320-3324; Hoffman et al., *Plant Mol. Biol.* (1988) 11:717-729), bean lectin (Voelker et al., *EMBO J.* (1987) 6:3571-3577), soybean lectin (Okamuro et al., *Proc. Natl. Acad. Sci. USA* (1986) 83:8240-8244), soybean Kunitz trypsin inhibitor (Perez-Grau et al., *Plant Cell* (1989) 1:095-1109), soybean β -conglycinin (Beachy et al., *EMBO J.* (1985) 4:3047-3053; pea vicilin (Higgins et al., *Plant Mol. Biol.* (1988) 11:683-695), pea convicilin (Newbiggin et al., *Planta* (1990) 180:461-470), pea legumin (Shirsat et al., *Mol. Gen. Genetics* (1989) 215:326-331); rapeseed napin (Radke et al., *Theor. Appl. Genet.* (1988) 75:685-694) as well as genes from monocotyledonous plants such as for maize 15 kD zein (Hoffman et al., *EMBO J.* (1987) 6:3213-3221), maize 18 kD oleosin (Lee et al., *Proc. Natl. Acad. Sci. USA* (1991) 88:6181-6185), barley β -hordein (Marri et al., *Plant Mol. Biol.* (1988) 10:359-366) and wheat glutenin (Colot et al., *EMBO J.* (1987) 6:3559-3564). Moreover, promoters of seed-specific genes operably linked to heterologous coding sequences in chimeric gene constructs also maintain their temporal and spatial expression pattern in transgenic plants. Such examples include use of *Arabidopsis thaliana* 2S seed storage protein gene promoter to express enkephalin peptides in *Arabidopsis* and *B. napus* seeds (Vandekerckhove et al., *Bio/Technology*

(1989) 7:929-932), bean lectin and bean β -phaseolin promoters to express luciferase (Riggs et al., *Plant Sci.* (1989) 63:47-57), and wheat glutenin promoters to express chloramphenicol acetyl transferase (Colot et al., *EMBO J.* 5 (1987) 6:3559-3564).

Of particular use in the expression of the nucleic acid fragment of the invention will be the heterologous promoters from several soybean seed storage protein genes such as those for the Kunitz trypsin inhibitor (Jofuku et al., *Plant Cell* (1989) 1:1079-1093; glycinin (Nielson et al., *Plant Cell* (1989) 1:313-328), and β -conglycinin (Harada et al., *Plant Cell* (1989) 1:415-425). Promoters of genes for α - and β -subunits of soybean β -conglycinin storage protein will be particularly useful in expressing 15 the mRNA or the antisense RNA in the cotyledons at mid- to late-stages of seed development (Beachy et al., *EMBO J.* (1985) 4:3047-3053) in transgenic plants. This is because there is very little position effect on their expression in transgenic seeds, and the two promoters show different 20 temporal regulation. The promoter for the α -subunit gene is expressed a few days before that for the β -subunit gene. This is important for transforming rapeseed where oil biosynthesis begins about a week before seed storage protein synthesis (Murphy et al., *J. Plant Physiol.* (1989) 25 135:63-69).

Also of particular use will be promoters of genes expressed during early embryogenesis and oil biosynthesis. The native regulatory sequences, including the native promoters, of the fatty acid desaturase genes expressing 30 the nucleic acid fragments of the invention can be used following their isolation by those skilled in the art. Heterologous promoters from other genes involved in seed oil biosynthesis, such as those for B. napus isocitrate lyase and malate synthase (Comai et al., *Plant Cell* (1989) 35 1:293-300), delta-9 desaturase from safflower (Thompson et al. *Proc. Natl. Acad. Sci. USA* (1991) 88:2578-2582) and castor (Shanklin et al., *Proc. Natl. Acad. Sci. USA* (1991) 88:2510-2514), acyl carrier protein (ACP) from Arabidopsis

(Post-Beittenmiller et al., *Nucl. Acids Res.* (1989) 17:1777), B. napus (Safford et al., *Eur. J. Biochem.* (1988) 174:287-295), and B. campestris (Rose et al., *Nucl. Acids Res.* (1987) 15:7197), β -ketoacyl-ACP synthetase from barley (Siggaard-Andersen et al., *Proc. Natl. Acad. Sci. USA* (1991) 88:4114-4118), and oleosin from Zea mays (Lee et al., *Proc. Natl. Acad. Sci. USA* (1991) 88:6181-6185), soybean (Genbank Accession No: X60773) and B. napus (Lee et al., *Plant Physiol.* (1991) 96:1395-1397) will be of use.

If the sequence of the corresponding genes is not disclosed or their promoter region is not identified, one skilled in the art can use the published sequence to isolate the corresponding gene and a fragment thereof containing the promoter. The partial protein sequences for the relatively-abundant enoyl-ACP reductase and acetyl-CoA carboxylase are also published (Slabas et al., *Biochim. Biophys. Acta* (1987) 877:271-280; Cottingham et al., *Biochim. Biophys. Acta* (1988) 954:201-207) and one skilled in the art can use these sequences to isolate the corresponding seed genes with their promoters. Similarly, the fragments of the present invention encoding fatty acid desaturases can be used to obtain promoter regions of the corresponding genes for use in expressing chimeric genes.

Attaining the proper level of expression of the nucleic acid fragments of the invention may require the use of different chimeric genes utilizing different promoters. Such chimeric genes can be transferred into host plants either together in a single expression vector or sequentially using more than one vector.

It is envisioned that the introduction of enhancers or enhancer-like elements into the promoter regions of either the native or chimeric nucleic acid fragments of the invention will result in increased expression to accomplish the invention. This would include viral enhancers such as that found in the 35S promoter (Odell et al., *Plant Mol. Biol.* (1988) 10:263-272), enhancers from the opine genes (Fromm et al., *Plant Cell* (1989) 1:977-984), or enhancers from any other source that result in increased

transcription when placed into a promoter operably linked to a nucleic acid fragment of the invention.

Of particular importance is the DNA sequence element isolated from the gene for the α -subunit of β -conglycinin

5 that can confer 40-fold seed-specific enhancement to a constitutive promoter (Chen et al., *Dev. Genet.* (1989) 10:112-122). One skilled in the art can readily isolate this element and insert it within the promoter region of any gene in order to obtain seed-specific enhanced
10 expression with the promoter in transgenic plants.

Insertion of such an element in any seed-specific gene that is expressed at different times than the β -conglycinin gene will result in expression in transgenic plants for a longer period during seed development.

15 The invention can also be accomplished by a variety of other methods to obtain the desired end. In one form, the invention is based on modifying plants to produce increased levels of mutant fatty acid desaturases by virtue of introducing more than one copy of the foreign gene
20 containing the nucleic acid fragments of the invention. In some cases, the desired level of polyunsaturated fatty acids may require introduction of foreign genes for more than one kind of mutant fatty acid desaturase.

Any 3' non-coding region capable of providing a
25 polyadenylation signal and other regulatory sequences that may be required for the proper expression of the nucleic acid fragments of the invention can be used to accomplish the invention. This would include 3' ends of the native
30 fatty acid desaturase(s), viral genes such as from the 35S or the 19S cauliflower mosaic virus transcripts, from the opine synthesis genes, ribulose 1,5-bisphosphate carboxylase, or chlorophyll a/b binding protein. There are numerous examples in the art that teach the usefulness of different 3' non-coding regions.

35 TRANSFORMATION METHODS

Various methods of transforming cells of higher plants according to the present invention are available to those skilled in the art (see EPO Pub. 0 295 959 A2 and

0 318 341 A1). Such methods include those based on transformation vectors utilizing the Ti and Ri plasmids of Agrobacterium spp. It is particularly preferred to use the binary type of these vectors. Ti-derived vectors transform a wide variety of higher plants, including monocotyledonous and dicotyledonous plants (Sukhapinda et al., *Plant Mol. Biol.* (1987) 8:209-216; Potrykus, *Mol. Gen. Genet.* (1985) 199:183). Other transformation methods are available to those skilled in the art, such as direct uptake of foreign DNA constructs (see EPO Pub. 0 295 959 A2), techniques of electroporation (Fromm et al., *Nature* (1986) (London) 319:791) or high-velocity ballistic bombardment with metal particles coated with the nucleic acid constructs (Kline et al., *Nature* (1987) (London) 327:70). Once transformed, the cells can be regenerated by those skilled in the art.

Of particular relevance are the recently described methods to transform foreign genes into commercially important crops, such as rapeseed (De Block et al., *Plant Physiol.* (1989) 91:694-701), sunflower (Everett et al., *Bio/Technology* (1987) 5:1201), and soybean (Christou et al., *Proc. Natl. Acad. Sci USA* (1989) 86:7500-7504).

APPLICATION TO PLANT BREEDING

The use of restriction fragment length polymorphism (RFLP) markers in plant breeding has been well-documented in the art (Tanksley et al., *Bio/Technology* (1989) 7:257-264). Thus, the nucleic acid fragments of the invention can be used as molecular markers for traits associated with mutant fatty acid desaturases. These traits will include altered levels of unsaturated fatty acids. The nucleic acid fragment of the invention can also be used to isolate the fatty acid desaturase gene from other mutant plants with altered levels of unsaturated fatty acids. Sequencing of these genes will reveal nucleotide differences that cause the alteration in levels of unsaturated fatty acids. Oligonucleotides designed around these differences may also be used in plant breeding as diagnostic markers to follow fatty acid variation. In one embodiment, oligonucleotides based on differences

between wt and mutant $\Delta 12$ des may be used as molecular markers in breeding canola lines with variant oil profiles.

EXAMPLES

The present invention is further defined in the following
 5 Examples, in which all parts and percentages are by weight and degrees are Celsius, unless otherwise stated. It should be understood that these Examples, while indicating preferred embodiments of the invention, are given by way of illustration only. From the above discussion and these Examples, one
 10 skilled in the art can ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

EXAMPLE 1

SEQUENCES OF MUTANT DELTA-12 FATTY ACID 15 DESATURASES FROM B. NAPUS

Primers specific for the FAD2 structural gene were used to clone the entire open reading frame (ORF) of the D and F forms of the gene by reverse transcription-polymerase chain
 20 reaction (RT-PCR) . The sequences of the primers used for isolation of the D form ORF of B. napus FAD2 gene are
 5'-CATGGGTGCAGGTGGAAGAATGC-3' (SEQ ID NO: 9); and
 5'-GTTTCTTCTTTGCTTCATAAC3' (SEQ ID NO: 10)

25 The sequences of the primers used to clone the F form ORF of B. napus FAD2 gene are
 5'-CATGGGTGCAGGTGGAAGAATGC-3' (SEQ ID NO: 11); and
 5'-TCTTTCACCATCATCATATCC-3' (SEQ ID NO: 12)

RNA from seeds of three lines, 1MC129, Q508 and Westar,
 30 was isolated by an acid guanidinium thiocyanate-phenol-chloroform extraction method (Chomczynski and Sacchi, 1987; *Analytical Biochemistry* 162, 156-159, 1987) . The total RNA was used as a template for reverse transcription and PCR

amplification by RNA PCR kit (Perkin Elmer) . The RT-PCR.
amplified fragments were cloned into pGEM-T® vector (Promega),
and then used for nucleotide sequence determination. The DNA
sequence of each gene from each line was determined from both
5 strands by dideoxy sequencing by Sanger et al. (Proc Natl Acad
Sci USA 74, 5463-5467).

The D gene of IMC129 contained a G to A transversion at
nucleotide 316 (from the translation initiation codon) of the
D gene in IMC129, compared to the sequence of Westar. The
10 transversion changes the codon at this position from GAG to
AAG and results in a substitution of glutamic acid for lysine.
The same base change was also detected in IMC129 when RNA from
leaf tissue was used as template. The G to A mutation at
nucleotide 316 was confirmed by sequencing several independent
15 clones containing fragments amplified directly from genomic
DNA of IMC129. These results eliminated the possibility of a
rare mutation introduced during reverse transcription and PCR
in the RT-PCR protocol. The mutation in the D form of delta-12
desaturase in IMC129 mapped to a conserved region of cloned
20 delta-12 and delta-15 membrane bound-desaturases (Table 2).

The sequence of the F form of delta-12 desaturase in
IMC129 was the same as the F form of delta-12 desaturase in
Westar.

For Q508, the sequence of the D form of delta-12
25 desaturase was the same as the D form of the IMC129 gene. This
was expected, as Q508 was derived by mutagenesis of IMC129.

Sequence analysis of the Q508 F form of delta-12
desaturase revealed a T to A transition at nucleotide 515,
compared to the wild-type Westar sequence. This mutation
30 results in a change from a CTC codon to a CAC codon,
substituting a histidine residue for the wild-type leucine
residue.

TABLE 2

Alignment of Amino Acid Sequences of Cloned Canola
Membrane Bound-Desaturases

<u>Desaturase Gene</u>	<u>Sequence^a</u>	<u>Position^b</u>
Canola-FAD2-D	HEC <u>G</u> H	110
Canola-FAD2-F	HEC <u>G</u> H	110
Canola FAD6 ^c	HDC <u>A</u> H	171
Canola-FAD3 ^d	HDC <u>G</u> H	97
Canola-FAD7 ^e	HDC <u>G</u> H	126

^aOne letter amino acid code; conservative substitutions
are underlined

^bPosition in gene product of first amino acid

^cFAD6 = Plastid delta-12

^dFAD3 = Microsomal delta-15

^eFAD7 = Plastid delta-15

EXAMPLE 2

GENE-SPECIFIC OLIGONUCLEOTIDE MARKERS FOR THE
MUTANT AND WILD TYPE DELTA-12 FATTY ACID DESATURASE GENES

The D form of IMC129 fad2 gene contains a G to A
transversion at nucleotide 316 from the translation
initiation codon. Two short oligonucleotide upstream (5')
primers, based on the single base change (G to A) between
the D form of the IMC129 and wild type FAD2 genes, were
designed. The sequences of the upstream (5') primers are
as follows:

5' gene-specific primer for wild type FAD2-D:

5'-GTCTGGGTCATAGCCCACG-3' (SEQ ID NO:13); and

5' gene-specific primer for IMC129 fad2-d:

5'-GTCTGGGTCATAGCCCACA-3' (SEQ ID NO:14).

A common downstream (3') primer (SEQ ID NO: 10) specific
for the D form of the FAD2 gene was used for both IMC129
and wild type FAD2 genes. These gene-specific primers were
used in a DNA based PCR diagnostic assay to genotype plants
carrying the mutant and/or wild type FAD2 genes.

Genomic DNA was isolated from leaf tissue of IMC129 and
Westar plants, and used as PCR templates. The PCR
amplification assays were carried out by using a gene
amplification kit (Perkin Elmer). The PCR conditions are

as follows: denaturing temperature, 95°C for 1 min; annealing temperature, 52°C for 1 min; amplification temperature 72°C for 1 min. Total 20 PCR cycles were extended. Under these conditions primers SEQ ID NO:13 and
5 SEQ ID NO:14 only amplified wild type FAD2-D and IMC 129 mutant fad2-d gene fragments, respectively.

The specificity of the gene-specific primers could be further improved by shortening the length of the primers and by replacing the base C with a T at the second position
10 from the 3' end of the oligonucleotide PCR primer for FAD2-D (SEQ ID NO:13). The sequences of the modified upstream (5') oligonucleotide PCR primers are as follows:

5' modified gene-specific primer for wild type FAD2-D:
15 5'-CTGGGTCATAGCCCATG-3' (SEQ ID NO:15); and

5' modified gene-specific primer for IMC129 fad2-d:
5'-CTGGGTCATAGCCCACA-3' (SEQ ID NO:16).

20 The same common downstream (3') oligonucleotide primer (SEQ ID NO:10) was used for amplifying FAD2-D and fad2-d. With the modified primers, the genotype for FAD2-D and fad2-d could be consistently distinguished after extended 30 cycle of PCR amplification. Therefore, the DNA based PCR assay
25 provided a simple and reliable method of genotyping B. Napus germplasms containing mutant and/or wild type FAD2 genes.

EXAMPLE 3

CONSTRUCTS FOR DOMINANT NEGATIVE SUPPRESSION 30 OF DELTA-12 FATTY ACID DESATURASE

The vector p2S212 was used to construct plasmids for dominant negative suppression experiments. One construct was prepared by inserting the full-length mutant D gene coding sequence (nucleotides 1 to 1155 of SEQ ID NO:3) in
35 sense orientation between the phaseolin promoter and phaseolin 3' poly A region of plasmid pCW108. The pCW108 vector contains the bean phaseolin promoter and 3' untranslated region and was derived from the commercially available pUC18 plasmid (Gibco-BRL) via plasmids AS3 and

pCW104. Plasmid AS3 contains 495 base pairs of the bean (*Phaseolus vulgaris*) phaseolin (7S seed storage protein) promoter starting with 5'-TGGTCTTTTGGT-3' followed by the entire 1175 base pairs of the 3' untranslated region of the same gene (see sequence descriptions in Doyle et al., (1986) *J. Biol. Chem.* 261:9228-9238 and Slightom et al., (1983) *Proc. Natl. Acad. Sci. USA*, 80:1897-1901. Further sequence description may be found in WO 9113993) cloned into the Hind III site of pUC18. The additional cloning sites of the pUC18 multiple cloning region (Eco RI, Sph I, Pst I and Sal I) were removed by digesting with Eco RI and Sal I, filling in the ends with Klenow and religating to yield the plasmid pCW104. A new multiple cloning site was created between the 495bp of the 5' phaseolin and the 1175bp of the 3' phaseolin by inserting a dimer of complementary synthetic oligonucleotides consisting of the coding sequence for a Nco I site (5'-CCATGG-3') followed by three filler bases (5'-TAG-3'), the coding sequence for a Sma I site (5'-CCCGGG-3'), the last three bases of a Kpn I site (5'-TAC-3'), a cytosine and the coding sequence for an Xba I site (5'-TCTAGA-3') to create the plasmid pCW108. This plasmid contains unique Nco I, Sma I, Kpn I and Xba I sites directly behind the phaseolin promoter.

The resulting 5'-phaseolin promoter-mutant fad2-phaseolin poly A-3' construct was excised and cloned between the EcoRI/SalI sites of pZS212, resulting in the plasmid designated pZPhMCFd2 (Figure 1). pZS212 is based on a vector which contains: (1) the chimeric gene nopaline synthase/neomycin phosphotransferase as a selectable marker for transformed plant cells (Brevan et al. (1984) *Nature* 304: 184-186), (2) the left and right borders of the T-DNA of the Ti plasmid (Brevan et al. (1984) *Nucl. Acids Res.* 12:8711-8720), (3) the *E. coli* lacZ α -complementing segment (Vieria and Messing (1982) *Gene* 19:259-267) with unique restriction endonuclease sites for Eco RI, Kpn I, Bam HI, and Sal I, (4) the bacterial replication origin from the *Pseudomonas* plasmid pVS1 (Itoh et al. (1984) *Plasmid*

11:206-220), and (5) the bacterial neomycin phosphotransferase gene from Tn5 (Berg et al. (1975) *Proc. Natnl. Acad. Sci. U.S.A.* 72:3628-3632) as a selectable marker for transformed A. tumefaciens. The nopaline synthase promoter in the plant selectable marker was replaced by the 35S promoter (Odell et al. (1985) *Nature*, 313:810-813) by a standard restriction endonuclease digestion and ligation strategy.

A second plasmid was constructed by inserting the full-length wild type canola D gene coding sequence (nucleotides 130 to 1281 of SEQ ID NO:1) into the NotI site of the canola napin promoter expression vector pIMC401 which contains a 2.2 kb napin expression cassette.

The canola napin promoter expression cassette in pIMC401 was constructed as follows: ten oligonucleotide primers were synthesized based upon the nucleotide sequence of napin lambda clone CGN1-2 published in European Patent Application EP 255378). The oligonucleotide sequences were:

- BR42 and BR43 corresponding to bases 1132 to 1156 (BR42) and the complement of bases 2248 to 2271 (BR43) of the sequence listed in Figure 2 of EP 255378.
- BR45 and BR46 corresponding to bases 1150 to 1170 (BR46) and the complement of bases 2120 to 2155 (BR45) of the sequence listed in Figure 2 of EP 255378. In addition BR46 had bases corresponding to a Sal I site (5'-GTCGAC-3') and a few additional bases (5'-TCAGGCCT-3') at its 5' end and BR45 had bases corresponding to a Bgl II site (5'-AGATCT-3') and two (5'-CT-3') additional bases at the 5' end of the primer,
- BR47 and BR48 corresponding to bases 2705 to 2723 (BR47) and bases 2643 to 2666 (BR48) of the sequence listed in Figure 2 of EP 255378. In addition BR47 had two (5'-CT-3') additional bases at the 5' end of the primer followed by bases corresponding to a Bgl II site (5'-AGATCT-3') followed by a few additional bases (5'-TCAGGCCT-3'),

- BR49 and BR50 corresponding to the complement of bases 3877 to 3897 (BR49) and the complement of bases 3985 to 3919 (BR50) of the sequence listed in Figure 2 of EP 255378. In addition BR49 had bases corresponding to a
5 Sal I site (5'-GTCGAC-3') and a few additional bases (5'-TCAGGCCT-3') at its 5' end,
- BR57 and BR58 corresponding to the complement of bases 3875 to 3888 (BR57) and bases 2700 to 2714 (BR58) of the
10 sequence listed in Figure 2 of EP 255378. In addition the 5' end of BR57 had some extra bases (5'-CCATGG-3') followed by bases corresponding to a Sac I site (5'-GAGCTC-3') followed by more additional bases (5'-GTCGACGAGG-3'). The 5' end of BR58 had additional
15 bases (5'-GAGCTC-3') followed by bases corresponding to a Nco I site (5'-CCATGG-3') followed by additional bases (5'-AGATCTGGTACC-3').
- BR61 and BR62 corresponding to bases 1846 to 1865 (BR61) and bases 2094 to 2114 (BR62) of the sequence listed in
20 Figure 2 of EP 255378. In addition the 5' end of BR 62 had additional bases (5'-GACA-3') followed by bases corresponding to a Bgl II site (5'-AGATCT-3') followed by a few additional bases (5'-GCGGCCGC-3').

Genomic DNA from the canola variety 'Hyola401' (Zeneca Seeds) was used as a template for PCR amplification of the
25 napin promoter and napin terminator regions. The promoter was first amplified using primers BR42 and BR43, and reamplified using primers BR45 and BR46. Plasmid pIMC01 was derived by digestion of the 1.0 kb promoter PCR product with SalI/BglII and ligation into SalI/BamHI digested
30 pBluescript SK⁺* (Stratagene). The napin terminator region was amplified using primers BR48 and BR50, and reamplified using primers BR47 and BR49. Plasmid pIMC06 was derived by digestion of the 1.2 kb terminator PCR product with
35 SalI/BglII and ligation into SalI/BglII digested pSP72 (Promega). Using pIMC06 as a template, the terminator region was reamplified by PCR using primer BR57 and primer BR58. Plasmid pIMC101 containing both the napin promoter and terminator was generated by digestion of the PCR

* trademark

product with SacI/NcoI and ligation into SacI/NcoI digested pIMC01. Plasmid pIMC101 contains a 2.2 kb napin expression cassette including complete napin 5' and 3' non-translated sequences and an introduced NcoI site at the translation start ATG. Primer BR61 and primer BR62 were used to PCR amplify an ~270 bp fragment from the 3' end of the napin promoter. Plasmid pIMC401 was obtained by digestion of the resultant PCR product with EcoRI/BglII and ligation into EcoRI/BglII digested pIMC101. Plasmid pIMC401 contains a 2.2 kb napin expression cassette lacking the napin 5' non-translated sequence and includes a NotI site at the transcription start.

The fragment containing the 5'-napin-fad2D-napin poly A-3' cassette was then inserted into the SalI site of pZS212, and the resulting 17.2 Kb plasmid was termed pIMC127 (Figure 2).

A third plasmid, pIMC135, was constructed in a manner similar to that described above for pIMC127. Plasmid pIMC135 contains a 5' cruciferin promoter fragment operably linked in sense orientation to the full-length wild-type coding sequence of SEQ ID NO:1, followed by a cruciferin 3' poly A fragment.

A fourth plasmid, pIMC140 was constructed in a manner similar to that described above. Plasmid pIMC140 contains a 5' napin promoter fragment operably linked in sense orientation to the full-length mutant Q508 F gene coding sequence (SEQ ID NO:7), followed by a 3' napin poly A fragment.

EXAMPLE 4

FATTY ACID PROFILES IN DOMINANT NEGATIVE SUPPRESSION PLANTS

The plasmids pZPhMCFd2, pIMC127, pIMC135 and pIMC140 were transferred by a freeze/thaw method (Holsters et al. (1978) *Mol Gen Genet* 163:181-187) to the Agrobacterium strain LBA4404/pAL4404 (Hockema et al. (1983), *Nature* 303:179-180).

Brassica napus cultivar "Westar" was transformed by co-cultivation of seedling pieces with disarmed Agrobacterium

tumefaciens strain LBA4404 carrying the appropriate binary vector.

B. napus seeds were sterilized by stirring in 10% Chlorox® bleach, 0.1% SDS for thirty min, and then rinsed
5 thoroughly with sterile distilled water. The seeds were germinated on sterile medium containing 30 mM CaCl₂ and 1.5% agar, and grown for six days in the dark at 24°C.

Liquid cultures of Agrobacterium for plant transformation were grown overnight at 28°C in Minimal A medium containing
10 100 mg/L kanamycin.

Minimal A Bacterial Growth Medium

Dissolve in distilled water:

10.5 grams potassium phosphate, dibasic
4.5 grams potassium phosphate, monobasic
15 1.0 gram ammonium sulfate
0.5 gram sodium citrate, dihydrate
Make up to 979 mL with distilled water
Autoclave
Add 20 mL filter-sterilized 10% sucrose
20 Add 1 mL filter-sterilized 1 N MgSO₄

The bacterial cells were pelleted by centrifugation and resuspended at a concentration of 10⁸ cells/mL in liquid Murashige and Skoog Minimal Organic medium (GIBCO; Cat.
25 No. 510-3118) containing 100 µM acetosyringone.

B. napus seedling hypocotyls were cut into 5 mm segments which were immediately placed into the bacterial suspension. After 30 mm, the hypocotyl pieces were removed from the bacterial suspension and placed onto BC-35 callus medium
30 containing 100 µM acetosyringone.

Brassica Callus Medium BC-35

Per liter:

Murashige and Skoog Minimal Organic Medium (MS salts, 100 mg/L i-inositol, 0.4 mg/L thiamine;
35 GIBCO #510-3118)
30 grams sucrose
18 grams mannitol

0.5 mg/L 2,4-D
0.3 mg/L kinetin
0.6% agarose
pH 5.8

5

The plant tissue and Agrobacteria were co-cultivated for three days at 24°C in dim light.

10 The co-cultivation was terminated by transferring the hypocotyl pieces to BC-35 callus medium containing 200 mg/L carbenicillin to kill the Agrobacteria, and 25 mg/L kanamycin to select for transformed plant cell growth. The seedling pieces were incubated on this medium for three weeks at 28°C under continuous light.

15 After four weeks, the segments were transferred to BS-48 regeneration medium containing 200 mg/L carbenicillin and 25 mg/L kanamycin.

Brassica Regeneration Medium BS-48

20 Murashige and Skoog Minimal Organic Medium
Gamborg B5 Vitamins (SIGMA #1019)
10 grams glucose
250 mg xylose
600 mg MES
0.4% agarose
25 pH 5.7

Filter-sterilize and add after autoclaving:

2.0 mg/L zeatin
0.1 mg/L IAA

30 Plant tissue was subcultured every two weeks onto fresh selective regeneration medium, under the same culture conditions described for the callus medium. Putatively transformed calli grew rapidly on regeneration medium; as calli reached a diameter of about 2 mm, they were removed
35 from the hypocotyl pieces and placed on the same medium lacking kanamycin.

Shoots began to appear within several weeks after transfer to BS-48 regeneration medium. As soon as the shoots formed discernable stems, they were excised from the

calli, transferred to MSV-1A elongation medium, and moved to a 16:8 h photoperiod at 24°C.

Brassica Shoot Elongation Medium MSV-1A

5 Murashige and Skoog Minimal Organic Medium
Gamborg B5 Vitamins
10 grams sucrose
0.6% agarose
pH 5.8

10

Once shoots had elongated several internodes, they were cut above the agar surface and the cut ends were dipped in Rootone. Treated shoots were planted directly into wet Metro-Mix 350 soilless potting medium. The pots were covered with plastic bags which were removed when the plants were clearly growing -- after about ten days.

15

Plants were grown under a 16:8 h photoperiod, with a daytime temperature of 23°C and a nighttime temperature of 17°C. When the primary flowering stem began to elongate, it was covered with a mesh pollen-containment bag to prevent outcrossing. Self-pollination was facilitated by shaking the plants several times each day.

20

Transgenic progeny plants containing pZPhMCFd2 were designated as the WS201 series. Plants transformed with pIMC127 were designated as the WS127 series. Plants transformed with pIMC135 were designated as the WS135 series. Plants transformed with pIMC140 were designated as the WS140 series. Seeds were obtained by selfing the T1 plants. Fatty acid profiles of the T2 seeds were determined as described in WO 93/11245. The results are shown in Tables 3 and 4 and Figures 3 and 4.

25

30

TABLE 3
T2 Seeds having Decreased
C18:2 (WS201¹ Transformants)².

Fatty Acid Composition(%)						
Line No.	Plant Series	C16:0	C18:0	C18:1	C18:2	C18:3
T300236	WS201	4.1	3.2	72.5	10.6	6.5
T300238	WS201	3.9	2.7	74.4	9.2	6.6
T300390	WS201	4.2	2.5	75.4	9.3	5.4
T300273	WS201	3.9	2.8	77.4	7.5	5.3
T300400	WS201	3.9	2.5	78.6	6.6	5.3
T300354	WS201	4.0	2.7	78.6	6.4	4.51

¹ WS201: phaseolin promoter/IMC129 mutant, sense orientation.

² Population of 168 selfed individuals from greenhouse.

As shown in Figure 3, a large proportion of the control WS127 plants have elevated levels of linoleic acid. This result is expected, since the delta-12 desaturase gene dosage is higher due to the extra copy of the wild-type delta-12 desaturase gene. A small proportion of WS127 plants show lower levels of linoleic acid, due to cosuppression.

In contrast, no WS201 plants had elevated levels of linoleic acid. This result confirms that the mutant delta-12 desaturase D form gene in WS201 plants is non-functional. Furthermore, a higher proportion of WS201 plants have decreased C18:2 (5-14%) compared to the proportion of WS127 control plants having decreased C18:2. The proportion of WS201 plants having decreased C18:2 is about 25-fold higher than the proportion of WS127 plants having decreased C18:2. The surprising inhibition of endogenous delta-12 desaturase activity by a mutant delta-12 gene product has been termed dominant negative suppression.

The fatty acid composition of seeds produced by representative dominant negative suppression T2 WS201 plants is shown in Table 3. The plants show an altered fatty acid composition, including decreased C18:2, increased C18:1, and decreased saturates.

A T2 generation plant is not homozygous for the introduced gene. Consequently, T3 and subsequent generations that are homozygous for the mutant delta-12 desaturase gene will have even lower levels of linoleic acid, from about 1% to about 10%, preferably from about 1% to about 6%. Levels of oleic acid in homozygous lines will be from 75% to about 88%, preferably from about 80% to about 88%.

The results observed with WS140 plants (containing a mutant Q508 F form delta-12 desaturase gene) are shown in Figure 4. None of the WS140 plants have elevated C18:2 levels, similar to the results obtained with WS201 transgenic plants. As expected, a large proportion of the control WS135 plants have elevated C18:2 levels. The proportion of WS140 and WS135 plants having decreased C18:2 levels is similar, indicating that expression of this particular mutant delta-12 desaturase gene product does not inhibit endogenous wild-type delta-12 desaturase gene product to an extent greater than that expected from cosuppression. The fatty acid composition of seeds produced by a representative T2 WS140 plant with decreased C18:2 levels is shown in Table 4.

TABLE 4

25 T2 Seed Having Decreased C18:2 (WS140¹ Transformants)².

		Fatty Acid Composition (%)				
<u>Line No.</u>	<u>Vector</u>	<u>C16:0</u>	<u>C18:0</u>	<u>C18:1</u>	<u>C18:2</u>	<u>C18:3</u>
T300435	pIMC140	3.8	3.5	73.7	9.7	6.11

¹ WS140: napin promoter/Q508 fad2 F mutation, sense orientation

² Population of 61 selfed individuals from greenhouse

SEQUENCE LISTING

(1) GENERAL INFORMATION:

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WILLIAM DEAN HITZ
GUO-HUA MIAO
ROBERT STEFAN REITER
- (ii) TITLE OF INVENTION: GENES FOR MUTANT MICROSOMAL
FATTY ACID DELTA-12
DESATURASES AND RELATED
ENZYMES FROM PLANTS
- (iii) NUMBER OF SEQUENCES: 17
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 - (E) COUNTRY: U.S.A.
 - (F) ZIP: 19898
- (v) COMPUTER READABLE FORM:
 - (A) MEDIUM TYPE: FLOPPY DISK
 - (B) COMPUTER: IBM PC COMPATIBLE
 - (C) OPERATING SYSTEM: MICROSOFT WINDOWS 95
 - (D) SOFTWARE: MICROSOFT OFFICE 97
- (vi) CURRENT APPLICATION DATA:
 - (A) APPLICATION NUMBER: 2,226,397
 - (B) FILING DATE: March 20, 1998
 - (C) CLASSIFICATION:
- (vii) PRIOR APPLICATION DATA:
 - (A) APPLICATION NUMBER: 08/256,047
 - (B) FILING DATE: NOVEMBER 17, 1992
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 - (C) TELEX:

(2) INFORMATION FOR SEQ ID NO:1:

- (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 1464 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

- (ix) FEATURE:
 (A) NAME/KEY: CDS
 (B) LOCATION: 130..1281

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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TCAAGAAAC ATG GGT GCA GGT GGA AGA ATG CAA GTG TCT CCT CCC TCC      168
      Met Gly Ala Gly Gly Arg Met Gln Val Ser Pro Pro Ser
              1              5              10

AAA AAG TCT GAA ACC GAC AAC ATC AAG CGC GTA CCC TGC GAG ACA CCG      216
Lys Lys Ser Glu Thr Asp Asn Ile Lys Arg Val Pro Cys Glu Thr Pro
      15              20              25

CCC TTC ACT GTC GGA GAA CTC AAG AAA GCA ATC CCA CCG CAC TGT TTC      264
Pro Phe Thr Val Gly Glu Leu Lys Lys Ala Ile Pro Pro His Cys Phe
      30              35              40              45

AAA CGC TCG ATC CCT CGC TCT TTC TCC TAC CTC ATC TGG GAC ATC ATC      312
Lys Arg Ser Ile Pro Arg Ser Phe Ser Tyr Leu Ile Trp Asp Ile Ile
              50              55              60

ATA GCC TCC TGC TTC TAC TAC GTC GCC ACC ACT TAC TTC CCT CTC CTC      360
Ile Ala Ser Cys Phe Tyr Tyr Val Ala Thr Thr Tyr Phe Pro Leu Leu
              65              70              75

CCT CAC CCT CTC TCC TAC TTC GCC TGG CCT CTC TAC TGG GCC TGC CAG      408
Pro His Pro Leu Ser Tyr Phe Ala Trp Pro Leu Tyr Trp Ala Cys Gln
              80              85              90

GGC TGC GTC CTA ACC GGC GTC TGG GTC ATA GCC CAC GAG TGC GGC CAC      456
Gly Cys Val Leu Thr Gly Val Trp Val Ile Ala His Glu Cys Gly His
              95              100              105

CAC GCC TTC AGC GAC TAC CAG TGG CTG GAC GAC ACC GTC GGC CTC ATC      504
His Ala Phe Ser Asp Tyr Gln Trp Leu Asp Asp Thr Val Gly Leu Ile
      110              115              120              125

TTC CAC TCC TTC CTC CTC GTC CCT TAC TTC TCC TGG AAG TAC AGT CAT      552
Phe His Ser Phe Leu Leu Val Pro Tyr Phe Ser Trp Lys Tyr Ser His
              130              135              140

CGA CGC CAC CAT TCC AAC ACT GGC TCC CTC GAG AGA GAC GAA GTG TTT      600
Arg Arg His His Ser Asn Thr Gly Ser Leu Glu Arg Asp Glu Val Phe
              145              150              155

GTC CCC AAG AAG AAG TCA GAC ATC AAG TGG TAC GGC AAG TAC CTC AAC      648
Val Pro Lys Lys Lys Ser Asp Ile Lys Trp Tyr Gly Lys Tyr Leu Asn
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[illegible]

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 384 amino acids
 (B) TYPE: amino acid
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

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          35           40           45
Ile Pro Arg Ser Phe Ser Tyr Leu Ile Trp Asp Ile Ile Ile Ala Ser
          50           55           60
Cys Phe Tyr Tyr Val Ala Thr Thr Tyr Phe Pro Leu Leu Pro His Pro
          65           70           75           80
Leu Ser Tyr Phe Ala Trp Pro Leu Tyr Trp Ala Cys Gln Gly Cys Val
          85           90           95
Leu Thr Gly Val Trp Val Ile Ala His Glu Cys Gly His His Ala Phe
          100          105          110
Ser Asp Tyr Gln Trp Leu Asp Asp Thr Val Gly Leu Ile Phe His Ser
          115          120          125
Phe Leu Leu Val Pro Tyr Phe Ser Trp Lys Tyr Ser His Arg Arg His
          130          135          140
His Ser Asn Thr Gly Ser Leu Glu Arg Asp Glu Val Phe Val Pro Lys
          145          150          155          160
Lys Lys Ser Asp Ile Lys Trp Tyr Gly Lys Tyr Leu Asn Asn Pro Leu
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Gly Arg Thr Val Met Leu Thr Val Gln Phe Thr Leu Gly Trp Pro Leu
          180          185          190
Tyr Leu Ala Phe Asn Val Ser Gly Arg Pro Tyr Asp Gly Gly Phe Ala
          195          200          205
Cys His Phe His Pro Asn Ala Pro Ile Tyr Asn Asp Arg Glu Arg Leu
          210          215          220
Gln Ile Tyr Ile Ser Asp Ala Gly Ile Leu Ala Val Cys Tyr Gly Leu
          225          230          235          240
Tyr Arg Tyr Ala Ala Val Gln Gly Val Ala Ser Met Val Cys Phe Tyr
          245          250          255
Gly Val Pro Leu Leu Ile Val Asn Gly Phe Leu Val Leu Ile Thr Tyr
          260          265          270
Leu Gln His Thr His Pro Ser Leu Pro His Tyr Asp Ser Ser Glu Trp
          275          280          285

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Asp Trp Leu Arg Gly Ala Leu Ala Thr Val Asp Arg Asp Tyr Gly Ile
 290 295 300
 Leu Asn Lys Val Phe His Asn Ile Thr Asp Thr His Val Ala His His
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 Leu Phe Ser Thr Met Pro His Tyr His Ala Met Glu Ala Thr Lys Ala
 325 330 335
 Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val
 340 345 350
 Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro
 355 360 365
 Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu
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(2) INFORMATION FOR SEQ ID NO:3:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 1155 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: Brassica napus
- (vii) IMMEDIATE SOURCE:
- (B) CLONE: IMC129
- (ix) FEATURE:
- (D) OTHER INFORMATION: G to A transversion
mutation at nucleotide 316
of the D form
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:
- | | |
|---|-----|
| ATG GGT GCA GGT GGA AGA ATG CAA GTG TCT CCT CCC TCC AAA AAG TCT | 48 |
| Met Gly Ala Gly Gly Arg Met Gln Val Ser Pro Pro Ser Lys Lys Ser | |
| 1 5 10 15 | |
| GAA ACC GAC AAC ATC AAG CGC GTA CCC TGC GAG ACA CCG CCC TTC ACT | 96 |
| Glu Thr Asp Asn Ile Lys Arg Val Pro Cys Glu Thr Pro Pro Phe Thr | |
| 20 25 30 | |
| GTC GGA GAA CTC AAG AAA GCA ATC CCA CCG CAC TGT TTC AAA CGC TCG | 144 |
| Val Gly Glu Leu Lys Lys Ala Ile Pro Pro His Cys Phe Lys Arg Ser | |
| 35 40 45 | |
| ATC CCT CGC TCT TTC TCC TAC CTC ATC TGG GAC ATC ATC ATA GCC TCC | 192 |
| Ile Pro Arg Ser Phe Ser Tyr Leu Ile Trp Asp Ile Ile Ile Ala Ser | |
| 50 55 60 | |
| TGC TTC TAC TAC GTC GCC ACC ACT TAC TTC CCT CTC CTC CCT CAC CCT | 240 |
| Cys Phe Tyr Tyr Val Ala Thr Thr Tyr Phe Pro Leu Leu Pro His Pro | |
| 65 70 75 80 | |

CTC	TCC	TAC	TTC	GCC	TGG	CCT	CTC	TAC	TGG	GCC	TGC	CAG	GGC	TGC	GTC	288
Leu	Ser	Tyr	Phe	Ala	Trp	Pro	Leu	Tyr	Trp	Ala	Cys	Gln	Gly	Cys	Val	
				85					90					95		
CTA	ACC	GGC	GTC	TGG	GTC	ATA	GCC	CAC	AAG	TGC	GGC	CAC	CAC	GCC	TTC	336
Leu	Thr	Gly	Val	Trp	Val	Ile	Ala	His	Lys	Cys	Gly	His	His	Ala	Phe	
			100					105					110			
AGC	GAC	TAC	CAG	TGG	CTG	GAC	GAC	ACC	GTC	GGC	CTC	ATC	TTC	CAC	TCC	384
Ser	Asp	Tyr	Gln	Trp	Leu	Asp	Asp	Thr	Val	Gly	Leu	Ile	Phe	His	Ser	
		115				120						125				
TTC	CTC	CTC	GTC	CCT	TAC	TTC	TCC	TGG	AAG	TAC	AGT	CAT	CGA	CGC	CAC	432
Phe	Leu	Leu	Val	Pro	Tyr	Phe	Ser	Trp	Lys	Tyr	Ser	His	Arg	Arg	His	
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CAT	TCC	AAC	ACT	GGC	TCC	CTC	GAG	AGA	GAC	GAA	GTG	TTT	GTC	CCC	AAG	480
His	Ser	Asn	Thr	Gly	Ser	Leu	Glu	Arg	Asp	Glu	Val	Phe	Val	Pro	Lys	
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AAG	AAG	TCA	GAC	ATC	AAG	TGG	TAC	GGC	AAG	TAC	CTC	AAC	AAC	CCT	TTG	528
Lys	Lys	Ser	Asp	Ile	Lys	Trp	Tyr	Gly	Lys	Tyr	Leu	Asn	Asn	Pro	Leu	
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GGA	CGC	ACC	GTG	ATG	TTA	ACG	GTT	CAG	TTC	ACT	CTC	GGC	TGG	CCT	TTG	576
Gly	Arg	Thr	Val	Met	Leu	Thr	Val	Gln	Phe	Thr	Leu	Gly	Trp	Pro	Leu	
			180					185					190			
TAC	TTA	GCC	TTC	AAC	GTC	TCG	GGG	AGA	CCT	TAC	GAC	GGC	GGC	TTC	GCT	624
Tyr	Leu	Ala	Phe	Asn	Val	Ser	Gly	Arg	Pro	Tyr	Asp	Gly	Gly	Phe	Ala	
		195				200					205					
TGC	CAT	TTC	CAC	CCC	AAC	GCT	CCC	ATC	TAC	AAC	GAC	CGC	GAG	CGT	CTC	672
Cys	His	Phe	His	Pro	Asn	Ala	Pro	Ile	Tyr	Asn	Asp	Arg	Glu	Arg	Leu	
	210					215					220					
CAG	ATA	TAC	ATC	TCC	GAC	GCT	GGC	ATC	CTC	GCC	GTC	TGC	TAC	GGT	CTC	720
Gln	Ile	Tyr	Ile	Ser	Asp	Ala	Gly	Ile	Leu	Ala	Val	Cys	Tyr	Gly	Leu	
225				230						235					240	
TAC	CGC	TAC	GCT	GCT	GTC	CAA	GGA	GTT	GCC	TCG	ATG	GTC	TGC	TTC	TAC	768
Tyr	Arg	Tyr	Ala	Ala	Val	Gln	Gly	Val	Ala	Ser	Met	Val	Cys	Phe	Tyr	
				245					250					255		
GGA	GTT	CCG	CTT	CTG	ATT	GTC	AAT	GGG	TTC	TTA	GTT	TTG	ATC	ACT	TAC	816
Gly	Val	Pro	Leu	Leu	Ile	Val	Asn	Gly	Phe	Leu	Val	Leu	Ile	Thr	Tyr	
			260					265					270			
TTG	CAG	CAC	ACG	CAT	CCT	TCC	CTG	CCT	CAC	TAT	GAC	TCG	TCT	GAG	TGG	864
Leu	Gln	His	Thr	His	Pro	Ser	Leu	Pro	His	Tyr	Asp	Ser	Ser	Glu	Trp	
		275					280				285					
GAT	TGG	TTG	AGG	GGA	GCT	TTG	GCC	ACC	GTT	GAC	AGA	GAC	TAC	GGA	ATC	912
Asp	Trp	Leu	Arg	Gly	Ala	Leu	Ala	Thr	Val	Asp	Arg	Asp	Tyr	Gly	Ile	
	290					295					300					
TTG	AAC	AAG	GTC	TTC	CAC	AAT	ATC	ACG	GAC	ACG	CAC	GTG	GCG	CAT	CAC	960
Leu	Asn	Lys	Val	Phe	His	Asn	Ile	Thr	Asp	Thr	His	Val	Ala	His	His	
305					310					315					320	
CTG	TTC	TCG	ACC	ATG	CCG	CAT	TAT	CAT	GCG	ATG	GAA	GCT	ACG	AAG	GCG	1008
Leu	Phe	Ser	Thr	Met	Pro	His	Tyr	His	Ala	Met	Glu	Ala	Thr	Lys	Ala	
				325					330					335		

ATA AAG CCG ATA CTG GGA GAG TAT TAT CAG TTC GAT GGG ACG CCG GTG	1056
Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val	
340 345 350	
GTT AAG GCG ATG TGG AGG GAG GCG AAG GAG TGT ATC TAT GTG GAA CCG	1104
Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro	
355 360 365	
GAC AGG CAA GGT GAG AAG AAA GGT GTG TTC TGG TAC AAC AAT AAG TTA T	1153
Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu	
370 375 380	
GA	1155

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 384 amino acids
 (B) TYPE: amino acid
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Met Gly Ala Gly Gly Arg Met Gln Val Ser Pro Pro Ser Lys Lys Ser	
1 5 10 15	
Glu Thr Asp Asn Ile Lys Arg Val Pro Cys Glu Thr Pro Pro Phe Thr	
20 25 30	
Val Gly Glu Leu Lys Lys Ala Ile Pro Pro His Cys Phe Lys Arg Ser	
35 40 45	
Ile Pro Arg Ser Phe Ser Tyr Leu Ile Trp Asp Ile Ile Ile Ala Ser	
50 55 60	
Cys Phe Tyr Tyr Val Ala Thr Thr Tyr Phe Pro Leu Leu Pro His Pro	
65 70 75 80	
Leu Ser Tyr Phe Ala Trp Pro Leu Tyr Trp Ala Cys Gln Gly Cys Val	
85 90 95	
Leu Thr Gly Val Trp Val Ile Ala His Lys Cys Gly His His Ala Phe	
100 105 110	
Ser Asp Tyr Gln Trp Leu Asp Asp Thr Val Gly Leu Ile Phe His Ser	
115 120 125	
Phe Leu Leu Val Pro Tyr Phe Ser Trp Lys Tyr Ser His Arg Arg His	
130 135 140	
His Ser Asn Thr Gly Ser Leu Glu Arg Asp Glu Val Phe Val Pro Lys	
145 150 155 160	
Lys Lys Ser Asp Ile Lys Trp Tyr Gly Lys Tyr Leu Asn Asn Pro Leu	
165 170 175	
Gly Arg Thr Val Met Leu Thr Val Gln Phe Thr Leu Gly Trp Pro Leu	
180 185 190	
Tyr Leu Ala Phe Asn Val Ser Gly Arg Pro Tyr Asp Gly Gly Phe Ala	
195 200 205	
Cys His Phe His Pro Asn Ala Pro Ile Tyr Asn Asp Arg Glu Arg Leu	
210 215 220	

Gln Ile Tyr Ile Ser Asp Ala Gly Ile Leu Ala Val Cys Tyr Gly Leu
 225 230 235 240
 Tyr Arg Tyr Ala Ala Val Gln Gly Val Ala Ser Met Val Cys Phe Tyr
 245 250 255
 Gly Val Pro Leu Leu Ile Val Asn Gly Phe Leu Val Leu Ile Thr Tyr
 260 265 270
 Leu Gln His Thr His Pro Ser Leu Pro His Tyr Asp Ser Ser Glu Trp
 275 280 285
 Asp Trp Leu Arg Gly Ala Leu Ala Thr Val Asp Arg Asp Tyr Gly Ile
 290 295 300
 Leu Asn Lys Val Phe His Asn Ile Thr Asp Thr His Val Ala His His
 305 310 315 320
 Leu Phe Ser Thr Met Pro His Tyr His Ala Met Glu Ala Thr Lys Ala
 325 330 335
 Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val
 340 345 350
 Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro
 355 360 365
 Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu
 370 375 380

(2) INFORMATION FOR SEQ ID NO:5:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 1155 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (vi) ORIGINAL SOURCE:
 - (A) ORGANISM: Brassica napus
- (ix) FEATURE:
 - (D) OTHER INFORMATION: Wild type F form.
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

ATG GGT GCA GGT GGA AGA ATG CAA GTG TCT CCT CCC TCC AAG AAG TCT	48
Met Gly Ala Gly Gly Arg Met Gln Val Ser Pro Pro Ser Lys Lys Ser	
1 5 10 15	
GAA ACC GAC ACC ATC AAG CGC GTA CCC TGC GAG ACA CCG CCC TTC ACT	96
Glu Thr Asp Thr Ile Lys Arg Val Pro Cys Glu Thr Pro Pro Phe Thr	
20 25 30	
GTC GGA GAA CTC AAG AAA GCA ATC CCA CCG CAC TGT TTC AAA CGC TCG	144
Val Gly Glu Leu Lys Lys Ala Ile Pro Pro His Cys Phe Lys Arg Ser	
35 40 45	

ATC Ile	CCT Pro	CGC Arg	TCT Ser	TTC Phe	TCC Ser	TAC Tyr	CTC Leu	ATC Ile	TGG Trp	GAC Asp	ATC Ile	ATC Ile	ATA Ile	GCC Ala	TCC Ser	192
	50					55					60					
TGC Cys	TTC Phe	TAC Tyr	TAC Tyr	GTC Val	GCC Ala	ACC Thr	ACT Thr	TAC Tyr	TTC Phe	CCT Pro	CTC Leu	CTC Leu	CCT Pro	CAC His	CCT Pro	240
65					70					75					80	
CTC Leu	TCC Ser	TAC Tyr	TTC Phe	GCC Ala	TGG Trp	CCT Pro	CTC Leu	TAC Tyr	TGG Trp	GCC Ala	TGC Cys	CAA Gln	GGG Gly	TGC Cys	GTC Val	288
				85					90					95		
CTA Leu	ACC Thr	GGC Gly	GTC Val	TGG Trp	GTC Val	ATA Ile	GCC Ala	CAC His	GAG Glu	TGC Cys	GGC Gly	CAC His	CAC His	GCC Ala	TTC Phe	336
			100					105					110			
AGC Ser	GAC Asp	TAC Tyr	CAG Gln	TGG Trp	CTT Leu	GAC Asp	GAC Asp	ACC Thr	GTC Val	GGT Gly	CTC Leu	ATC Ile	TTC Phe	CAC His	TCC Ser	384
		115				120						125				
TTC Phe	CTC Leu	CTC Leu	GTC Val	CCT Pro	TAC Tyr	TTC Phe	TCC Ser	TGG Trp	AAG Lys	TAC Tyr	AGT Ser	CAT His	CGC Arg	AGC Ser	CAC His	432
	130					135					140					
CAT His	TCC Ser	AAC Asn	ACT Thr	GGC Gly	TCC Ser	CTC Leu	GAG Glu	AGA Arg	GAC Asp	GAA Glu	GTG Val	TTT Phe	GTC Val	CCC Pro	AAG Lys	480
145					150					155					160	
AAG Lys	AAG Lys	TCA Ser	GAC Asp	ATC Ile	AAG Lys	TGG Trp	TAC Tyr	GGC Gly	AAG Lys	TAC Tyr	CTC Leu	AAC Asn	AAC Asn	CCT Pro	TTG Leu	528
				165					170					175		
GGA Gly	CGC Arg	ACC Thr	GTG Val	ATG Met	TTA Leu	ACG Thr	GTT Val	CAG Gln	TTC Phe	ACT Thr	CTC Leu	GGC Gly	TGG Trp	CCG Pro	TTG Leu	576
			180					185					190			
TAC Tyr	TTA Leu	GCC Ala	TTC Phe	AAC Asn	GTC Val	TCG Ser	GGA Gly	AGA Arg	CCT Pro	TAC Tyr	GAC Asp	GGC Gly	GGC Gly	TTC Phe	CGT Arg	624
		195				200						205				
TGC Cys	CAT His	TTC Phe	CAC His	CCC Pro	AAC Asn	GCT Ala	CCC Pro	ATC Ile	TAC Tyr	AAC Asn	GAC Asp	CGC Arg	GAG Glu	CGT Arg	CTC Leu	672
	210					215					220					
CAG Gln	ATA Ile	TAC Tyr	ATC Ile	TCC Ser	GAC Asp	GCT Ala	GGC Gly	ATC Ile	CTC Leu	GCC Ala	GTC Val	TGC Cys	TAC Tyr	GGT Gly	CTC Leu	720
225					230					235					240	
TTC Phe	CGT Arg	TAC Tyr	GCC Ala	GCC Ala	GGC Gly	CAG Gln	GGA Gly	GTG Val	GCC Ala	TCG Ser	ATG Met	GTC Val	TGC Cys	TTC Phe	TAC Tyr	768
				245					250					255		
GGA Gly	GTC Val	CCG Pro	CTT Leu	CTG Leu	ATT Ile	GTC Val	AAT Asn	GGT Gly	TTC Phe	CTC Leu	GTG Val	TTG Leu	ATC Ile	ACT Thr	TAC Tyr	816
			260					265					270			
TTG Leu	CAG Gln	CAC His	ACG Thr	CAT His	CCT Pro	TCC Ser	CTG Leu	CCT Pro	CAC His	TAC Tyr	GAT Asp	TCG Ser	TCC Ser	GAG Glu	TGG Trp	864
		275					280					285				
GAT Asp	TGG Trp	TTC Phe	AGG Arg	GGA Gly	GCT Ala	TTG Leu	GCT Ala	ACC Thr	GTT Val	GAC Asp	AGA Arg	GAC Asp	TAC Tyr	GGA Gly	ATC Ile	912
	290					295					300					

49

TTG AAC AAG GTC TTC CAC AAT ATT ACC GAC ACG CAC GTG GCC CAT CAT	960
Leu Asn Lys Val Phe His Asn Ile Thr Asp Thr His Val Ala His His	
305 310 315 320	
CCG TTC TCC ACG ATG CCG CAT TAT CAC GCG ATG GAA GCT ACC AAG GCG	1008
Pro Phe Ser Thr Met Pro His Tyr His Ala Met Glu Ala Thr Lys Ala	
325 330 335	
ATA AAG CCG ATA CTG GGA GAG TAT TAT CAG TTC GAT GGG ACG CCG GTG	1056
Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val	
340 345 350	
GTT AAG GCG ATG TGG AGG GAG GCG AAG GAG TGT ATC TAT GTG GAA CCG	1104
Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro	
355 360 365	
GAC AGG CAA GGT GAG AAG AAA GGT GTG TTC TGG TAC AAC AAT AAG TTA T	1153
Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu	
370 375 380	
GA	1155

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 384 amino acids
 (B) TYPE: amino acid
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

Met Gly Ala Gly Gly Arg Met Gln Val Ser Pro Pro Ser Lys Lys Ser	
1 5 10 15	
Glu Thr Asp Thr Ile Lys Arg Val Pro Cys Glu Thr Pro Pro Phe Thr	
20 25 30	
Val Gly Glu Leu Lys Lys Ala Ile Pro Pro His Cys Phe Lys Arg Ser	
35 40 45	
Ile Pro Arg Ser Phe Ser Tyr Leu Ile Trp Asp Ile Ile Ile Ala Ser	
50 55 60	
Cys Phe Tyr Tyr Val Ala Thr Thr Tyr Phe Pro Leu Leu Pro His Pro	
65 70 75 80	
Leu Ser Tyr Phe Ala Trp Pro Leu Tyr Trp Ala Cys Gln Gly Cys Val	
85 90 95	
Leu Thr Gly Val Trp Val Ile Ala His Glu Cys Gly His His Ala Phe	
100 105 110	
Ser Asp Tyr Gln Trp Leu Asp Asp Thr Val Gly Leu Ile Phe His Ser	
115 120 125	
Phe Leu Leu Val Pro Tyr Phe Ser Trp Lys Tyr Ser His Arg Ser His	
130 135 140	
His Ser Asn Thr Gly Ser Leu Glu Arg Asp Glu Val Phe Val Pro Lys	
145 150 155 160	
Lys Lys Ser Asp Ile Lys Trp Tyr Gly Lys Tyr Leu Asn Asn Pro Leu	
165 170 175	

50

Gly Arg Thr Val Met Leu Thr Val Gln Phe Thr Leu Gly Trp Pro Leu
 180 185 190
 Tyr Leu Ala Phe Asn Val Ser Gly Arg Pro Tyr Asp Gly Gly Phe Arg
 195 200 205
 Cys His Phe His Pro Asn Ala Pro Ile Tyr Asn Asp Arg Glu Arg Leu
 210 215 220
 Gln Ile Tyr Ile Ser Asp Ala Gly Ile Leu Ala Val Cys Tyr Gly Leu
 225 230 235 240
 Phe Arg Tyr Ala Ala Gly Gln Gly Val Ala Ser Met Val Cys Phe Tyr
 245 250 255
 Gly Val Pro Leu Leu Ile Val Asn Gly Phe Leu Val Leu Ile Thr Tyr
 260 265 270
 Leu Gln His Thr His Pro Ser Leu Pro His Tyr Asp Ser Ser Glu Trp
 275 280 285
 Asp Trp Phe Arg Gly Ala Leu Ala Thr Val Asp Arg Asp Tyr Gly Ile
 290 295 300
 Leu Asn Lys Val Phe His Asn Ile Thr Asp Thr His Val Ala His His
 305 310 315 320
 Pro Phe Ser Thr Met Pro His Tyr His Ala Met Glu Ala Thr Lys Ala
 325 330 335
 Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val
 340 345 350
 Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro
 355 360 365
 Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu
 370 375 380

(2) INFORMATION FOR SEQ ID NO:7:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 1155 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (vi) ORIGINAL SOURCE:
 - (A) ORGANISM: Brassica napus
- (vii) IMMEDIATE SOURCE:
 - (B) CLONE: IMC Q508
- (ix) FEATURE:
 - (D) OTHER INFORMATION: T to A transversion
mutation at nucleotide 515
of the F form

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

ATG	GGT	GCA	GGT	GGA	AGA	ATG	CAA	GTG	TCT	CCT	CCC	TCC	AAG	AAG	TCT	48
Met	Gly	Ala	Gly	Gly	Arg	Met	Gln	Val	Ser	Pro	Pro	Ser	Lys	Lys	Ser	
1				5					10					15		
GAA	ACC	GAC	ACC	ATC	AAG	CGC	GTA	CCC	TGC	GAG	ACA	CCG	CCC	TTC	ACT	96
Glu	Thr	Asp	Thr	Ile	Lys	Arg	Val	Pro	Cys	Glu	Thr	Pro	Pro	Phe	Thr	
			20					25					30			
GTC	GGA	GAA	CTC	AAG	AAA	GCA	ATC	CCA	CCG	CAC	TGT	TTC	AAA	CGC	TCG	144
Val	Gly	Glu	Leu	Lys	Lys	Ala	Ile	Pro	Pro	His	Cys	Phe	Lys	Arg	Ser	
			35				40					45				
ATC	CCT	CGC	TCT	TTC	TCC	TAC	CTC	ATC	TGG	GAC	ATC	ATC	ATA	GCC	TCC	192
Ile	Pro	Arg	Ser	Phe	Ser	Tyr	Leu	Ile	Trp	Asp	Ile	Ile	Ile	Ala	Ser	
	50					55					60					
TGC	TTC	TAC	TAC	GTC	GCC	ACC	ACT	TAC	TTC	CCT	CTC	CTC	CCT	CAC	CCT	240
Cys	Phe	Tyr	Tyr	Val	Ala	Thr	Thr	Tyr	Phe	Pro	Leu	Leu	Pro	His	Pro	
65					70					75					80	
CTC	TCC	TAC	TTC	GCC	TGG	CCT	CTC	TAC	TGG	GCC	TGC	CAA	GGG	TGC	GTC	288
Leu	Ser	Tyr	Phe	Ala	Trp	Pro	Leu	Tyr	Trp	Ala	Cys	Gln	Gly	Cys	Val	
				85					90					95		
CTA	ACC	GGC	GTC	TGG	GTC	ATA	GCC	CAC	GAG	TGC	GGC	CAC	CAC	GCC	TTC	336
Leu	Thr	Gly	Val	Trp	Val	Ile	Ala	His	Glu	Cys	Gly	His	His	Ala	Phe	
			100					105					110			
AGC	GAC	TAC	CAG	TGG	CTT	GAC	GAC	ACC	GTC	GGT	CTC	ATC	TTC	CAC	TCC	384
Ser	Asp	Tyr	Gln	Trp	Leu	Asp	Asp	Thr	Val	Gly	Leu	Ile	Phe	His	Ser	
		115					120					125				
TTC	CTC	CTC	GTC	CCT	TAC	TTC	TCC	TGG	AAG	TAC	AGT	CAT	CGC	AGC	CAC	432
Phe	Leu	Leu	Val	Pro	Tyr	Phe	Ser	Trp	Lys	Tyr	Ser	His	Arg	Ser	His	
	130					135					140					
CAT	TCC	AAC	ACT	GGC	TCC	CTC	GAG	AGA	GAC	GAA	GTG	TTT	GTC	CCC	AAG	480
His	Ser	Asn	Thr	Gly	Ser	Leu	Glu	Arg	Asp	Glu	Val	Phe	Val	Pro	Lys	
145					150					155					160	
AAG	AAG	TCA	GAC	ATC	AAG	TGG	TAC	GGC	AAG	TAC	CAC	AAC	AAC	CCT	TTG	528
Lys	Lys	Ser	Asp	Ile	Lys	Trp	Tyr	Gly	Lys	Tyr	His	Asn	Asn	Pro	Leu	
				165					170					175		
GGA	CGC	ACC	GTG	ATG	TTA	ACG	GTT	CAG	TTC	ACT	CTC	GGC	TGG	CCG	TTG	576
Gly	Arg	Thr	Val	Met	Leu	Thr	Val	Gln	Phe	Thr	Leu	Gly	Trp	Pro	Leu	
			180					185					190			
TAC	TTA	GCC	TTC	AAC	GTC	TCG	GGA	AGA	CCT	TAC	GAC	GGC	GGC	TTC	CGT	624
Tyr	Leu	Ala	Phe	Asn	Val	Ser	Gly	Arg	Pro	Tyr	Asp	Gly	Gly	Phe	Arg	
		195					200					205				
TGC	CAT	TTC	CAC	CCC	AAC	GCT	CCC	ATC	TAC	AAC	GAC	CGC	GAG	CGT	CTC	672
Cys	His	Phe	His	Pro	Asn	Ala	Pro	Ile	Tyr	Asn	Asp	Arg	Glu	Arg	Leu	
	210					215					220					
CAG	ATA	TAC	ATC	TCC	GAC	GCT	GGC	ATC	CTC	GCC	GTC	TGC	TAC	GGT	CTC	720
Gln	Ile	Tyr	Ile	Ser	Asp	Ala	Gly	Ile	Leu	Ala	Val	Cys	Tyr	Gly	Leu	
225					230					235					240	
TTC	CGT	TAC	GCC	GCC	GGC	CAG	GGA	GTG	GCC	TCG	ATG	GTC	TGC	TTC	TAC	768
Phe	Arg	Tyr	Ala	Ala	Gly	Gln	Gly	Val	Ala	Ser	Met	Val	Cys	Phe	Tyr	
				245					250					255		

GGA	GTC	CCG	CTT	CTG	ATT	GTC	AAT	GGT	TTC	CTC	GTG	TTG	ATC	ACT	TAC	816
Gly	Val	Pro	Leu	Leu	Ile	Val	Asn	Gly	Phe	Leu	Val	Leu	Ile	Thr	Tyr	
			260					265					270			
TTG	CAG	CAC	ACG	CAT	CCT	TCC	CTG	CCT	CAC	TAC	GAT	TCG	TCC	GAG	TGG	864
Leu	Gln	His	Thr	His	Pro	Ser	Leu	Pro	His	Tyr	Asp	Ser	Ser	Glu	Trp	
		275					280				285					
GAT	TGG	TTC	AGG	GGA	GCT	TTG	GCT	ACC	GTT	GAC	AGA	GAC	TAC	GGA	ATC	912
Asp	Trp	Phe	Arg	Gly	Ala	Leu	Ala	Thr	Val	Asp	Arg	Asp	Tyr	Gly	Ile	
	290					295					300					
TTG	AAC	AAG	GTC	TTC	CAC	AAT	ATT	ACC	GAC	ACG	CAC	GTG	GCC	CAT	CAT	960
Leu	Asn	Lys	Val	Phe	His	Asn	Ile	Thr	Asp	Thr	His	Val	Ala	His	His	
305					310					315					320	
CCG	TTC	TCC	ACG	ATG	CCG	CAT	TAT	CAC	GCG	ATG	GAA	GCT	ACC	AAG	GCG	1008
Pro	Phe	Ser	Thr	Met	Pro	His	Tyr	His	Ala	Met	Glu	Ala	Thr	Lys	Ala	
				325					330					335		
ATA	AAG	CCG	ATA	CTG	GGA	GAG	TAT	TAT	CAG	TTC	GAT	GGG	ACG	CCG	GTG	1056
Ile	Lys	Pro	Ile	Leu	Gly	Glu	Tyr	Tyr	Gln	Phe	Asp	Gly	Thr	Pro	Val	
			340					345					350			
GTT	AAG	GCG	ATG	TGG	AGG	GAG	GCG	AAG	GAG	TGT	ATC	TAT	GTG	GAA	CCG	1104
Val	Lys	Ala	Met	Trp	Arg	Glu	Ala	Lys	Glu	Cys	Ile	Tyr	Val	Glu	Pro	
		355					360					365				
GAC	AGG	CAA	GGT	GAG	AAG	AAA	GGT	GTG	TTC	TGG	TAC	AAC	AAT	AAG	TTA	T 1153
Asp	Arg	Gln	Gly	Glu	Lys	Lys	Gly	Val	Phe	Trp	Tyr	Asn	Asn	Lys	Leu	
	370					375					380					
GA																1155

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 384 amino acids
 (B) TYPE: amino acid
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

Met	Gly	Ala	Gly	Gly	Arg	Met	Gln	Val	Ser	Pro	Pro	Ser	Lys	Lys	Ser	
1				5					10					15		
Glu	Thr	Asp	Thr	Ile	Lys	Arg	Val	Pro	Cys	Glu	Thr	Pro	Pro	Phe	Thr	
			20					25					30			
Val	Gly	Glu	Leu	Lys	Lys	Ala	Ile	Pro	Pro	His	Cys	Phe	Lys	Arg	Ser	
		35					40					45				
Ile	Pro	Arg	Ser	Phe	Ser	Tyr	Leu	Ile	Trp	Asp	Ile	Ile	Ile	Ala	Ser	
	50					55					60					
Cys	Phe	Tyr	Tyr	Val	Ala	Thr	Thr	Tyr	Phe	Pro	Leu	Leu	Pro	His	Pro	
65					70					75					80	
Leu	Ser	Tyr	Phe	Ala	Trp	Pro	Leu	Tyr	Trp	Ala	Cys	Gln	Gly	Cys	Val	
				85					90					95		
Leu	Thr	Gly	Val	Trp	Val	Ile	Ala	His	Glu	Cys	Gly	His	His	Ala	Phe	
			100					105					110			

53

Ser Asp Tyr Gln Trp Leu Asp Asp Thr Val Gly Leu Ile Phe His Ser
 115 120 125
 Phe Leu Leu Val Pro Tyr Phe Ser Trp Lys Tyr Ser His Arg Ser His
 130 135 140
 His Ser Asn Thr Gly Ser Leu Glu Arg Asp Glu Val Phe Val Pro Lys
 145 150 155 160
 Lys Lys Ser Asp Ile Lys Trp Tyr Gly Lys Tyr His Asn Asn Pro Leu
 165 170 175
 Gly Arg Thr Val Met Leu Thr Val Gln Phe Thr Leu Gly Trp Pro Leu
 180 185 190
 Tyr Leu Ala Phe Asn Val Ser Gly Arg Pro Tyr Asp Gly Gly Phe Arg
 195 200 205
 Cys His Phe His Pro Asn Ala Pro Ile Tyr Asn Asp Arg Glu Arg Leu
 210 215 220
 Gln Ile Tyr Ile Ser Asp Ala Gly Ile Leu Ala Val Cys Tyr Gly Leu
 225 230 235 240
 Phe Arg Tyr Ala Ala Gly Gln Gly Val Ala Ser Met Val Cys Phe Tyr
 245 250 255
 Gly Val Pro Leu Leu Ile Val Asn Gly Phe Leu Val Leu Ile Thr Tyr
 260 265 270
 Leu Gln His Thr His Pro Ser Leu Pro His Tyr Asp Ser Ser Glu Trp
 275 280 285
 Asp Trp Phe Arg Gly Ala Leu Ala Thr Val Asp Arg Asp Tyr Gly Ile
 290 295 300
 Leu Asn Lys Val Phe His Asn Ile Thr Asp Thr His Val Ala His His
 305 310 315 320
 Pro Phe Ser Thr Met Pro His Tyr His Ala Met Glu Ala Thr Lys Ala
 325 330 335
 Ile Lys Pro Ile Leu Gly Glu Tyr Tyr Gln Phe Asp Gly Thr Pro Val
 340 345 350
 Val Lys Ala Met Trp Arg Glu Ala Lys Glu Cys Ile Tyr Val Glu Pro
 355 360 365
 Asp Arg Gln Gly Glu Lys Lys Gly Val Phe Trp Tyr Asn Asn Lys Leu
 370 375 380

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 23 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

CATGGGTGCA GGTGGAAGAA TGC

(2) INFORMATION FOR SEQ ID NO:10:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 21 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

GTTTCTTCTT TGCTTCATAA C

21

(2) INFORMATION FOR SEQ ID NO:11:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 23 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

CATGGGTGCA GGTGGAAGAA TGC

23

(2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 21 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

TCTTTCACCA TCATCATATC C

21

(2) INFORMATION FOR SEQ ID NO:13:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 19 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

GTCTGGGTCA TAGCCCACG

19

(2) INFORMATION FOR SEQ ID NO:14:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 19 base pairs
 - (B) TYPE: nucleic acid
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

GTCTGGGTCA TAGCCCACA

19

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 17 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

CTGGGTCATA GCCCATG

17

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 17 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

CTGGGTCATA GCCCACA

17

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 5 amino acids
 (B) TYPE: amino acid
 (C) STRANDEDNESS:
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: YES

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(ix) FEATURE:

(A) NAME/KEY: Modified-site
 (B) LOCATION: 2
 (D) OTHER INFORMATION: /product= "Asp or Glu"

(ix) FEATURE:

(A) NAME/KEY: Modified-site
 (B) LOCATION: 4
 (D) OTHER INFORMATION: /product= "Ala or Gly"

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

His Xaa Cys Xaa His
 1 5

CLAIMS:

1. A method for altering fatty acid composition in plant seeds, comprising the steps of:
 - a) introducing a recombinant nucleic acid construct into a plant, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Glu located in a His-Glu-Cys-Gly-His motif wherein said at least one mutation results in a dominant negative suppression of endogenous fatty acid desaturase activity in said plant; and
 - b) obtaining progeny from said plant, said progeny producing said seeds having an oleic acid content of from about 69% to about 90%.
2. The method of claim 1, wherein said progeny produce seeds having a linoleic acid content of from about 1% to about 10%.
3. The method of claim 1, wherein said progeny produce seeds having an oleic acid content of from about 74% to about 90%.
4. The method of claim 3, wherein said progeny produce seeds having an oleic acid content of from about 80% to about 90%.
5. The method of claim 3, wherein said progeny produce seeds having an oleic acid content of from about 75% to about 88%.
6. The method of claim 5, wherein said progeny produce seeds having an oleic acid content of from about 80% to about 88%.
7. The method of claim 1, wherein said progeny produce seeds having an α -linolenic acid content of from about 1% to about 10%.

8. The method of claim 2, wherein said progeny produce seeds having a linoleic acid content of from about 1% to about 6%.

9. The method of claim 1, further comprising the step of introducing a recombinant nucleic acid construct into said plant, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having a mutation located in a His (Asp/Glu) Cys Gly His motif.

10. The method of claim 9, wherein said mutation in said delta-15 fatty acid desaturase protein is in a His-Asp-Cys-Gly-His motif.

11. The method of claim 10, wherein said mutation in said delta-15 fatty acid desaturase protein is the substitution of Lys for Asp in said motif.

12. The method of claim 10, wherein said progeny produce seeds having an α -linolenic acid content of from about 1% to about 5%.

13. The method of claim 1, wherein said plant is soybean.

14. The method of claim 1, wherein said plant is rapeseed.

15. The method of claim 1, wherein said plant is cotton.

16. The method of claim 1, wherein said plant is corn.

17. The method of claim 1, wherein said plant is safflower.

18. The method of claim 1, wherein said seed-specific regulatory sequence is a bean β -phaseolin promoter.

19. The method of claim 1, wherein said seed-specific regulatory sequence is an α subunit of soybean β -conglycinin promoter.

20. The method of claim 1, wherein said seed-specific regulatory sequence is a maize 18 kd oleosin promoter.

21. The method of claim 1, wherein said seed-specific regulatory sequence is a maize 15 kd zein promoter.

22. The method of claim 1, wherein said seed-specific regulatory sequence is a *Brassica napin* promoter.

23. A method of making a vegetable oil, comprising extracting said oil from seeds of one or more plants, said plants having a recombinant nucleic acid construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Glu located in a His-Glu-Cys-Gly-His motif, wherein said oil has an oleic acid content of from about 69% to about 90%.

24. A recombinant nucleic acid construct effective for increasing oleic acid content when expressed in seeds, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having at least one mutation which renders said desaturase protein nonfunctional, said mutation being a substitution of Lys for Glu in a His-Glu-Cys-Y-His (SEQ ID NO: 17) amino acid motif, wherein Y is selected from the group consisting of Gly and Ala.

25. A method for altering fatty acid composition in plant seeds, comprising the steps of:

a) introducing a recombinant nucleic acid construct into a plant, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Asp located in a His-Asp-Cys-Gly-His motif wherein said at least one mutation results in a dominant negative suppression of endogenous fatty acid desaturase activity in said plant; and

b) obtaining progeny from said plant, said progeny producing said seeds having an oleic acid content of from about 69% to about 90%.

26. The method of claim 25, wherein said progeny produce seeds having a linoleic acid content of from about 1% to about 10%.

27. The method of claim 25, wherein said progeny produce seeds having an oleic acid content of from about 74% to about 90%.

28. The method of claim 27, wherein said progeny produce seeds having an oleic acid content of from about 80% to about 90%.

29. The method of claim 27, wherein said progeny produce seeds having an oleic acid content of from about 75% to about 88%.

30. The method of claim 29, wherein said progeny produce seeds having an oleic acid content of from about 80% to about 88%.

31. The method of claim 25, wherein said progeny produce seeds having an α -linolenic acid content of from about 1% to about 10%.

32. The method of claim 26, wherein said progeny produce seeds having a linoleic acid content of from about 1% to about 6%.

33. The method of claim 25, further comprising the step of introducing a recombinant nucleic acid construct into said plant, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-12 fatty acid desaturase coding sequence encoding a delta-12 fatty acid desaturase protein having a mutation located in a His (Asp/Glu) Cys Gly His motif.

34. The method of claim 33, wherein said mutation in said delta-12 fatty acid desaturase protein is in a His-Glu-Cys-Gly-His motif.

35. The method of claim 34, wherein said mutation in said delta-12 fatty acid desaturase protein is the substitution of Lys for Glu in said motif.

36. The method of claim 34, wherein said progeny produce seeds having an α -linolenic acid content of from about 1% to about 5%.

37. The method of claim 25, wherein said plant is soybean.

38. The method of claim 25, wherein said plant is rapeseed.

39. The method of claim 25, wherein said plant is cotton.

40. The method of claim 25, wherein said plant is corn.

41. The method of claim 25, wherein said plant is safflower.

42. The method of claim 25, wherein said seed-specific regulatory sequence is a bean β -phaseolin promoter.

43. The method of claim 25, wherein said seed-specific regulatory sequence is an α subunit of soybean β -conglycinin promoter.

44. The method of claim 25, wherein said seed-specific regulatory sequence is a maize 18 kd oleosin promoter.

45. The method of claim 25, wherein said seed-specific regulatory sequence is a maize 15 kd zein promoter.

46. The method of claim 25, wherein said seed-specific regulatory sequence is a *Brassica* napin promoter.

47. A method of making a vegetable oil, comprising extracting said oil from seeds of one or more plants, said plants having a recombinant nucleic acid construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation of a substitution of Lys for Asp located in a His-Asp-Cys-Gly-His motif, wherein said oil has an oleic acid content of from about 69% to about 90%.

48. A recombinant nucleic acid construct effective for increasing oleic acid content when expressed in seeds, said construct comprising at least one seed-specific regulatory sequence operably linked in sense orientation to a mutant delta-15 fatty acid desaturase coding sequence encoding a delta-15 fatty acid desaturase protein having at least one mutation which renders said desaturase protein nonfunctional, said mutation being a substitution of Lys for Asp in a His-Asp-Cys-Y-His (SEQ ID NO: 17) amino acid motif, wherein Y is selected from the group consisting of Gly and Ala.

49. A plant cell comprising the construct of claim 24 or 48.

1/4

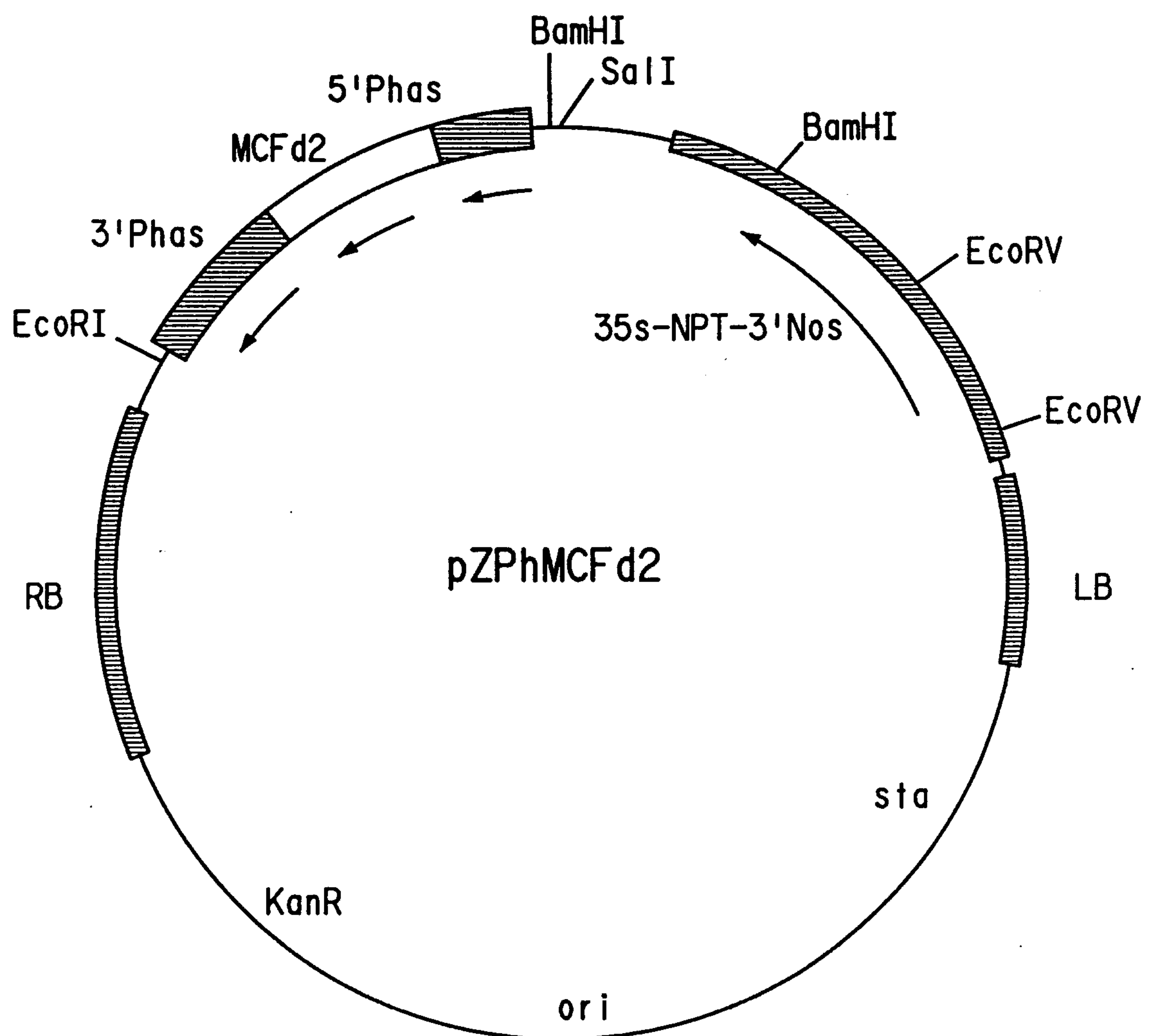


FIG. 1

2/4

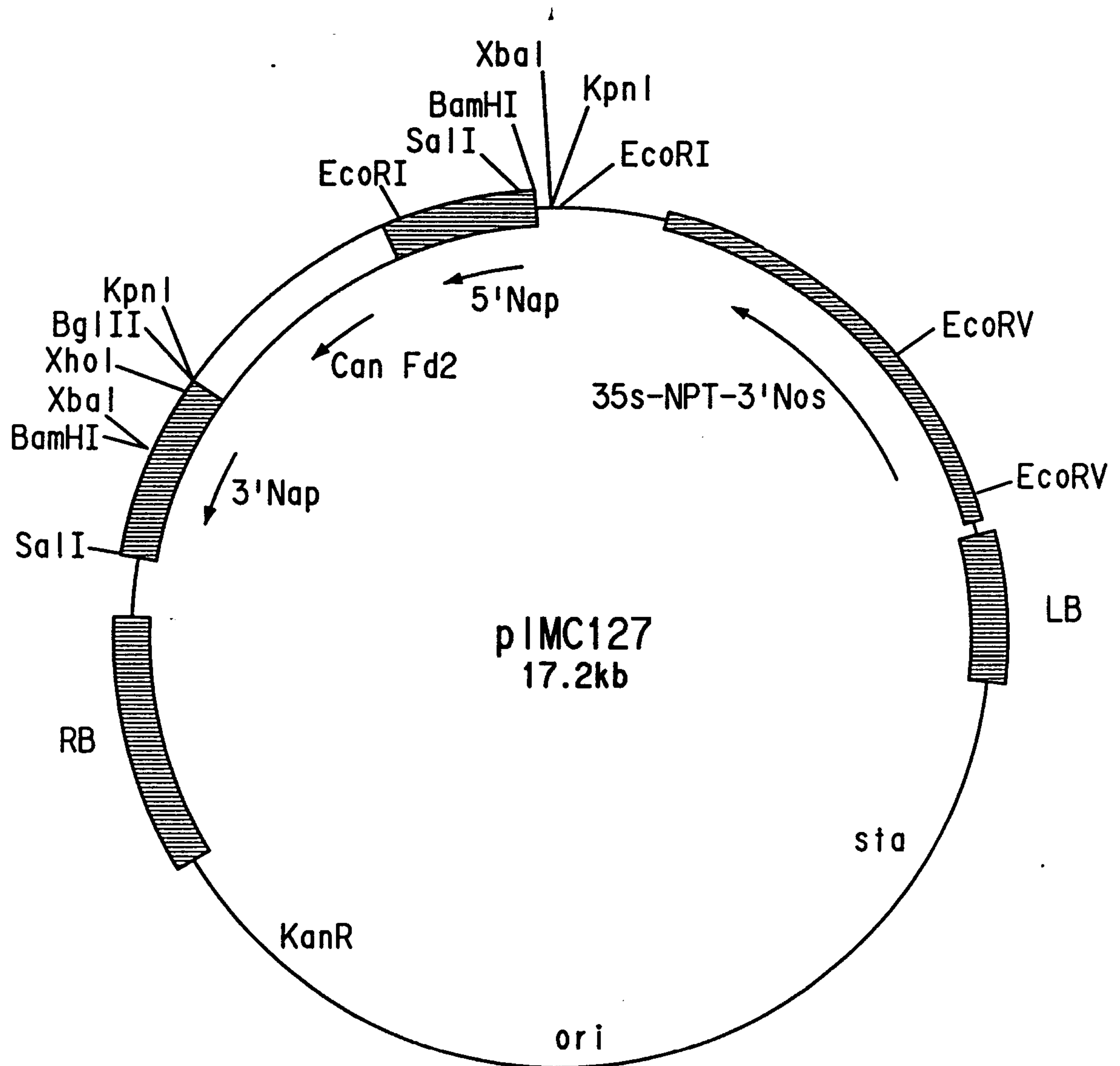


FIG.2

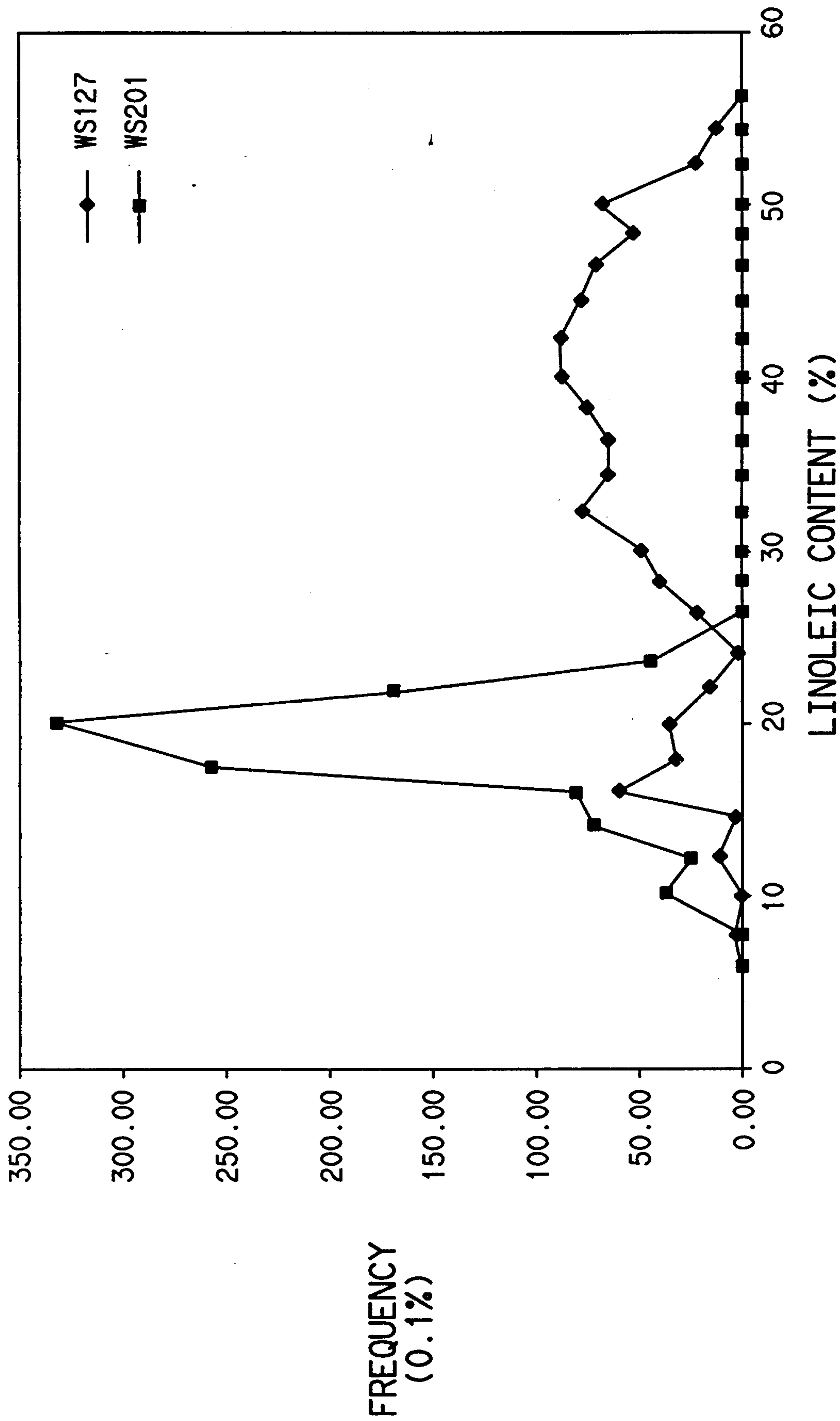


FIG. 3

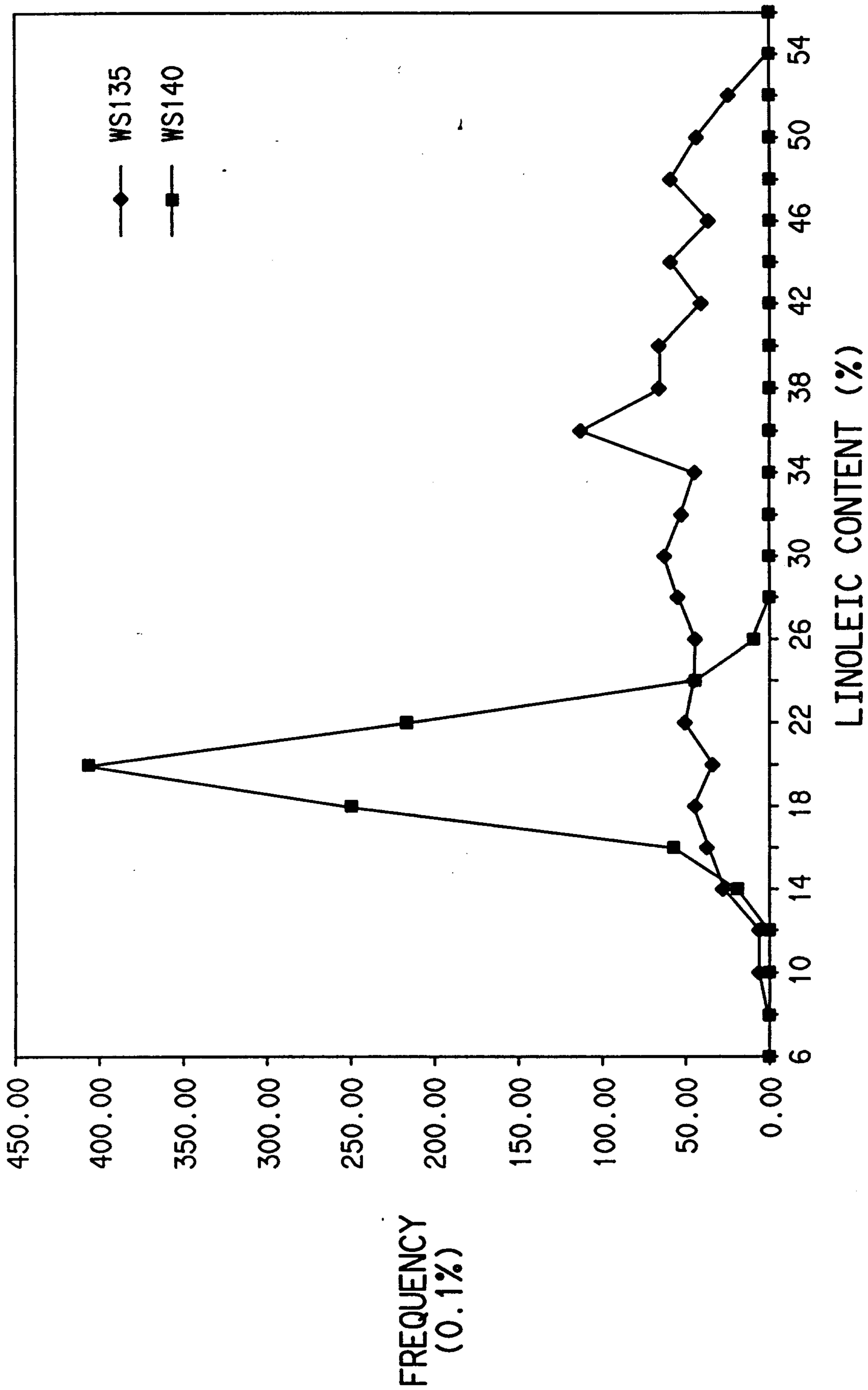


FIG. 4