# $\Delta^{11}$-fatty-acid desaturase 1.14.19.5

## 1 Nomenclature

**EC number**
1.14.19.5

**Systematic name**
acyl-CoA,hydrogen donor:oxygen $\Delta^{11}$-oxidoreductase

**Recommended name**
$\Delta^{11}$-fatty-acid desaturase

**Synonyms**
APTQ desaturase <13> [15]
Cro-Z/E11 <6> [8]
$\Delta^{11}$ desaturase <3,4,10> [6,12,13,16]
$\Delta^{11}$-(Z)-desaturase <1,2> [4]
$\Delta^{11}$-desaturase <5,6,8,9,14,15,16> (<5> several $\Delta^{11}$-desaturase systems: one produces a large quantitiy of (Z)-11-hexadecenoic acid and another produces (E)1-tetradecenoic acid [7]) [2,7,8,9,17,18]
$\Delta^{11}$-fatty-acid desaturase <17,18> [19,20]
$\Delta^{11}$-myristoyl-CoA desaturase <4> [1]
$\Delta^{11}$-palmitoyl-CoA-desaturase <4> [3]
$\Delta^{11}$-palmitoyl-coenzyme A desaturase <6> [8]
Dpu-$\Delta^{11}$-APSQ <17> [19]
Dpu-$\Delta^{11}$-LPAE <17> [19]
LATPG1 <18> [20]
Lca-KPVQ <14> [17]
OfuZ/E11 protein <15> [18]
OscZ/E11 protein <16> [18]
PDesat-Tn$\Delta^{11}$ Z protein <7> [11]
Sls//E11 <10> [6]
TpDESN <9> [2]
Z/E11-desaturase <6> [8]
acyl-CoA <6> [8]
acyl-CoA $\Delta^{11}$-desaturase <7> [11]
acyl-CoA desaturase <14> [17]
bifunctional $\Delta^{11}$-desaturase <4> [12]
bifunctional Z-$\Delta^{11}$-desaturase <13> [15]
fatty acid $\Delta^{11}$-desaturase <6> [8]
sphingolipid long chain base $\Delta^{8}$ desaturase <8> [9]

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**CAS registry number**
77000-04-5

## 2 Source Organism

<1> *Bombyx mori* [4]
<2> *Manduca sexta* [4]
<3> *Trichoplusia ni* [13]
<4> *Spodoptera littoralis* [1,3,10,12,13,16]
<5> *Choristoneura fumiferana* [7]
<6> *Choristoneura rosaceana* (UNIPROT accession number: Q8ISS3) [8]
<7> *Trichoplusia ni* (UNIPROT accession number: O44390) [11]
<8> *Thaumetopoea pityocampa* [9]
<9> *Thalassiosira pseudonana* (UNIPROT accession number: Q6RT18) [2]
<10> *Spodoptera littoralis* (UNIPROT accession number: Q6US81) [6]
<11> *Argyrotaenia velutinana* [5]
<12> *Ostrinia scapulalis* [14]
<13> *Manduca sexta* (UNIPROT accession number: Q4A181) [15]
<14> *Lampronia capitella* (UNIPROT accession number: B6CBS5) [17]
<15> *Ostrinia furnacalis* [18]
<16> *Ostrinia scapulalis* (UNIPROT accession number: Q2V0N6) [18]
<17> *Dendrolimus punctatus* [19]
<18> *Ostrinia latipennis* [20]

## 3 Reaction and Specificity

**Catalyzed reaction**
acyl-CoA + reduced acceptor + $O_2$ = $\Delta^{11}$-acyl-CoA + acceptor + 2 $H_2O$ (<4> active site modeling [12])

**Reaction type**
oxidation
reduction

**Natural substrates and products**
**S** palmitic acid + reduced acceptor + $O_2$ <9> (<9> enzyme is not involved in production of polyunsaturated fatty acids [2]) (Reversibility: ?) [2]
**P** hexadec-11-enoic acid + acceptor + $H_2O$
**S** stearoyl-CoA + reduced acceptor + $O_2$ <7> (Reversibility: ?) [11]
**P** oleoyl-CoA + acceptor + $H_2O$
**S** Additional information <4,7,14,15,16,17> (<7> all unsaturated pheromone products are produced via a $\Delta^{11}$ Z-desaturation mechanism [11]; <4> the enzyme is involved in the biosynthesis of Spodoptera littoralis sex pheromone [1]; <14> catalyses key reactions leading to mono- and di-unsaturated fatty acyl-moities [17]; <15,16> $\Delta^{11}$-desaturase is involved in the biosynthesis of Z/E11-14:OAc [18]; <17> heterologous expression

in yeast shows that Dpu-$\Delta^{11}$-LPAE produces large amounts of $\Delta^{11}$-monoenoic acids, in particular the Z11-16:Me and Z11-18:Me in a 1.5:1 ratio. When supplemented with the Z9-16:Me, yeast extracts of Dpu-D112-LPAE contained no 9,11-16:Me, but contain small amounts of E9,Z11-and E9,E11-16:Me when supplemented with E9-16:Me [19]; <17> heterologous expression in yeast shows that Dpu-$\Delta^{11}$-APSQ produces a series of monounsaturated products. These monoenes are identified as $\Delta^{8}$-12:Me, $\Delta^{8}$-14:Me and $\Delta$ 8-16:Me. When supplemented with the Z9-16:acid, yeast cells transformed with Dpu-$\Delta^{11}$-APSQ do not produce the $\Delta^{8}$-unsaturated fatty acid methyl esters, but produce significant amount of di-unsaturated 9,11-$C_{16}$ methylesters [19]) (Reversibility: ?) [1,11,17,18,19]

**P** ?

**Substrates and products**

- **S** (Z)-11-tetradecenoyl-CoA + reduced acceptor + $O_2$ <4> (<4> (E,E)-10,12-tetradecadienoic acid is produced from (Z)-11-tetradecenoic acid by desaturation and concomitant migration of the precursor double bond [12]) (Reversibility: ?) [12]
- **P** (E,E)-10,12-tetradecadienoyl + acceptor + $H_2O$
- **S** methyl myristate + reduced electron acceptor + $O_2$ <6,11> (Reversibility: ?) [5,8]
- **P** methyl (11E)-tetradec-11-enoate + methyl (11Z)-tetradec-11-enoate + acceptor + $H_2O$ (<6> in the ratio 7:1 [8])
- **S** myristic acid + NADH + ? <4> (<4> 50% of the activity with palmitic acid [3]) (Reversibility: ?) [3]
- **P** tetradec-11-enoic acid + $NAD^+$ + ?
- **S** myristic acid + reduced acceptor + $O_2$ <10> (Reversibility: ?) [6]
- **P** (Z)-tetradec-11-enoic acid + (E)-tetradec-11-enoic acid + acceptor + $H_2O$
- **S** myristoyl-CoA + reduced acceptor + $O_2$ <4> (<4> reaction involves a first slow, isotpe-sensitive $C_{11}$-H bond cleavage, with probable formation of an unstable intermediate, followed by a second fast $C_{12}$-H bond removal [1]) (Reversibility: ?) [1]
- **P** (Z)-tridec-11-enoyl-CoA + (E)-tridec-11-enoyl-CoA + acceptor + $H_2O$
- **S** palmitic acid + NADH + ? <4> (Reversibility: ?) [3]
- **P** (Z)-hexadec-11-enoic acid + $NAD^+$ + ?
- **S** palmitic acid + reduced acceptor + $O_2$ <8> (Reversibility: ?) [9]
- **P** (Z)-11-hexadecenoic acid + acceptor + $H_2O$
- **S** palmitic acid + reduced acceptor + $O_2$ <1,2,10> (<1,2> pro-(R) C(11)-H and pro-(R) C(12)-H stereospecificity [4]) (Reversibility: ?) [4,6]
- **P** (Z)-hexadec-11-enoic acid + acceptor + $H_2O$
- **S** palmitic acid + reduced acceptor + $O_2$ <9> (<9> enzyme is not involved in production of polyunsaturated fatty acids [2]) (Reversibility: ?) [2]
- **P** hexadec-11-enoic acid + acceptor + $H_2O$
- **S** palmitoyl-CoA + NADH + ? <4> (Reversibility: ?) [3]
- **P** (Z)-hexadec-11-enoyl-CoA + $NAD^+$ + ?

**S** stearic acid + NADH + ? <4> (<4> 18% of the activity with palmitic acid [3]) (Reversibility: ?) [3]
**P** oleic acid + $NAD^+$ + ?
**S** stearoyl-CoA + reduced acceptor + $O_2$ <7> (Reversibility: ?) [11]
**P** oleoyl-CoA + acceptor + $H_2O$
**S** Additional information <4,5,7,10,11,13,14,15,16,17,18> (<7> all unsaturated pheromone products are produced via a $\Delta^{11}$ Z-desaturation mechanism [11]; <4> the enzyme is involved in the biosynthesis of Spodoptera littoralis sex pheromone [1]; <5> several $\Delta^{11}$-desaturase systems: one produces a large quantitiy of (Z)-11-hexadecenoic acid and another produces (E)1-tetradecenoic acid [7]; <11> the enzyme produces a mixture of Z/E11-14:acids and exhibits no activity with $C_{16}$ and $C_{18}$ saturated fatty acid precursors [5]; <10> the recombinant enzyme expressed in yeast produces a mixture of E11-14:fatty acid, Z11-14:fatty acid, Z11-16:fatty acid and Z-11-18:fatty acid [6]; <13> MsexAPTQ desaturase catalyses the production of Z11-hexadecenoate and (Z10,E12)- and (E10,E12)-hexadecadienoates via 1,4-desaturation of the Z11-16 substrate, in a stereospecific manner, GC-MS analysis of conjugated dienes formed by APTQ desaturase in recombinant Saccharomyces cerevisiae cells, overview [15]; <4> substrate specificity, the enzyme catalyzes the formation of methylenecyclopropanes by enzymatic desaturation of 11-cyclopropylundecanoic acid and its disubstituted cis-and trans-derivatives 11-(cis-2-methylcyclopropyl)undecanoic acid, 11-(cis-2-ethylcyclopropyl)undecanoic acid, 11-(cis-2-propylcyclopropyl)undecanoic acid, 11-(trans-2-methylcyclopropyl)undecanoic acid, 11-(trans-2-ethylcyclopropyl)undecanoic acid, and 11-(trans-2-propylcyclopropyl)undecanoic acid, detailed overview [16]; <14> catalyses key reactions leading to mono- and di-unsaturated fatty acyl-moities [17]; <15,16> $\Delta^{11}$-desaturase is involved in the biosynthesis of Z/E11-14:OAc [18]; <17> heterologous expression in yeast shows that Dpu-D11-LPAE produces large amounts of $\Delta^{11}$-monoenoic acids, in particular the Z11-16:Me and Z11-18:Me in a 1.5:1 ratio. When supplemented with the Z9-16:Me, yeast extracts of Dpu-D112-LPAE contained no 9,11-16:Me, but contain small amounts of E9,Z11-and E9,E11-16:Me when supplemented with E9-16:Me [19]; <17> heterologous expression in yeast shows that Dpu-$\Delta^{11}$-APSQ produces a series of mono-unsaturated products. These monoenes are identified as $\Delta^8$-12:Me, $\Delta$ 8-14:Me and $\Delta^8$-16:Me. When supplemented with the Z9-16:acid, yeast cells transformed with Dpu-$\Delta^{11}$-APSQ do not produce the $\Delta^8$-unsaturated fatty acid methyl esters, but produce significant amount of di-unsaturated 9,11-$C_{16}$ methylesters [19]; <18> in the presence of tetradecanoic acid, only (E)-11-tetradecenoic acid is produced in Sf9 cells infected with recombinant baculoviruses expressing LATPG1. Sf9 cells infected with the control virus do not show $\Delta^{11}$-desaturase activity [20]) (Reversibility: ?) [1,5,6,7,11,15,16,17,18,19,20]
**P** ?

**Inhibitors**

11-fluorotetradecanoic acid <4> (<4> 50% inhibition at 1:1 substrate/inhibitor ratio [10]) [10]
KCN <4> (<4> 83% inhibition by 1 mM, 95% inhibition by 5 mM [3]) [3]
$NaN_3$ <4> (<4> 92% inhibition b [3]) [3]

**Cofactors/prosthetic groups**

NADH <4> (<4> NADPH is a less effective elctron donor. Highest activity with 1 mM of electron donors, reduced activity below [3]) [3]

**pH-Optimum**

6.8-7.2 <4> [3]

**Temperature optimum (°C)**

25 <4> (<4> assay at [16]) [3,16]

## 4 Enzyme Structure

**Molecular weight**

37800 <18> (<18> calculated from cDNA [20]) [20]

## 5 Isolation/Preparation/Mutation/Application

**Source/tissue**

abdomen <12> (<12> terminal abdominal segments with pheromone gland of female adults, RT-PCR [14]) [14]
fat body <17> [19]
pheromone gland <4,6,8,11,13,17> (<11> abdominal [5]) [3,5,8,9,10,15,19]
Additional information <12> (<12> in intersegmental membrane, 8th - 9th, in-situ hybridization [14]; <12> not in head, thorax, abdomen exclusive of the terminal abdominal segments [14]) [14]

**Localization**

microsome <4> [3]

**Cloning**

<3> (expressed in yeast) [13]
<4> (expressed as polyhistidine-tagged protein in elongase 1 and $\Delta^9$ desaturase-deficient yeast cells) [12]
<4> (expressed in yeast) [13]
<4> (expression in Saccharomyces cerevisiae Δelo1/Δole mutant strain, which is both elongase 1 and $\Delta^9$ desaturase-deficient, using a $Cu^+2$ inducible expression vector, the recombinant expression leads to producing large quantities of $C_{11}$-monounsaturated fatty acids, mainly (Z)-11-hexadecenoic acid, (E,E)-10,12-tetradecadienoic acid, minor amounts of (E,Z)-10,12-hexadecadienoic acid, and very low amounts of (E,Z)-10,12-tetradecadienoic isomer) [12]

<6> [8]
<7> (genetic trans-formation of a desaturase-deficient strain of the yeast Saccharomyces cerevisiae with an expression plasmid encoding PDesat-Tn $\Delta^{11}$Z results in complementation of the strain's fatty acid auxotrophy and the production of $\Delta^{11}$ Z-unsaturated fatty acids) [11]
<10> (expression in yeast) [6]
<11> [5]
<13> (gene d2, DNA and amino acid sequence determination and analysis, phylogenetic analysis, functional expression of MsexAPTQ desaturase in Saccharomyces cerevisiae strain W303) [15]
<14> (into a copper-inducible pYEX vector to assess its desaturase activity and then transformed into a desaturase- and elongase-deficient mutant ole1 elo1 yeast strain) [17]
<16> (partial cDNAs are amplified and cloned into the vector pCold I DNA, recombinant proteins are produced by Escherichia coli BL21 cells and used as antigens to raise antibodies in mice) [18]
<17> (heterologously expressed in Saccharomyces cerevisiae) [19]
<18> (C-terminal His-tagged fusion protein expressed using recombinant baculoviruses) [20]

## 6 Stability

**Storage stability**
<4>, -80°C, stable for at least 1 h [3]

## References

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