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(54) **Title:** PROCESS FOR THE PREPARATION OF FATTY ACIDS

(57) **Abstract:** A process for the preparation of a material comprising conjugated isomers of a polyunsaturated fatty acid comprises: treating a first fatty acid mixture comprising saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in the presence of ethanol to form (i) a solid fraction and (ii) a liquid fraction comprising a second fatty acid mixture, wherein the second fatty acid mixture has a higher molar ratio of total polyunsaturated fatty acids to total saturated and monounsaturated fatty acids than the first fatty acid mixture; separating the solid fraction and the liquid fraction; and subjecting the second fatty acid mixture or a derivative or reaction product thereof to treatment with a base in the presence of a solvent, to form conjugated isomers of at least some of the polyunsaturated fatty acids.

WO 2006/082093 A1

PROCESS FOR THE PREPARATION OF FATTY ACIDS

This invention relates to a process for the preparation of a material comprising fatty acids, in particular conjugated isomers of a polyunsaturated fatty acid, to products obtainable by the process and to food products, food supplements or pharmaceutical products comprising the products.

Conjugated isomers of polyunsaturated fatty acids are known to provide health benefits and have been used in food products. Typically, these products comprise linoleic acid isomers with the cis 9, trans 11 and trans 10, cis 12 isomers often being the most abundantly present isomers in these materials, in general in a 1:1 weight ratio.

Conjugated polyunsaturated fatty acids are compounds that contain adjacent carbon-carbon double bonds (eg, one or more $-\text{CH}=\text{CH}-\text{CH}=\text{CH}-$ linkages). Conjugated polyunsaturated fatty acids can be prepared from the corresponding non-conjugated fatty acids. For example, EP-A-0902082 describes a process for producing conjugated polyunsaturated fatty acids, such as conjugated linoleic acid (CLA). The process involves subjecting non-conjugated polyunsaturated fatty acids to a treatment with a base in a solvent which is an alcohol with at least 3 carbon atoms and at least two hydroxyl groups.

Typical sources of polyunsaturated fatty acids, such as safflower oil, generally contain about 80% by weight linoleic acid, 12% by weight oleic acid and about 8% by weight saturated fatty acids. Using fractionation and distillation, only the saturated fatty acids can be removed which means that the linoleic acid content cannot exceed 90% by weight. Accordingly, the amount of conjugated linoleic acid that can be produced in a subsequent

conjugation step, such as that described above, is also limited to a maximum of 90% by weight.

There is therefore a need for materials that contain high amounts of conjugated polyunsaturated fatty acids.

US 6395778 describes a process for making an enriched mixture comprising a non-conjugated polyunsaturated fatty acid ester. The process involves a first step of transesterification of an oil to form fatty acid esters, adding urea to the mixture of fatty acid esters and cooling or concentrating the resulting mixture. The precipitate comprises urea and the saturated fatty acid esters and the liquid fraction contains more of the polyunsaturated fatty acid esters. The specific fatty acid esters disclosed are non-conjugated and contain at least five carbon-carbon double bonds. There is no suggestion that the process can be carried out using free fatty acids.

EP-A-1211304 discloses a method for isolating non-conjugated unsaturated fatty acids by selective crystallisation using urea in methanol as solvent.

There is no disclosure in US 6395778 or EP-A-1211304 of subsequent conjugation of the fatty acids.

We have found a process for producing conjugated polyunsaturated fatty acids in surprisingly high yields. Moreover, when carried out on polyunsaturated fatty acids containing two carbon-carbon double bonds, the process results in fewer of the trans, trans isomers of the fatty acids relative to cis, trans isomers. It has been unexpectedly found that the effectiveness of the process is highly dependent on the solvent that is employed in the process.

Accordingly, the present invention provides a process for the preparation of a material comprising a conjugated polyunsaturated fatty acid, which comprises:

treating a first fatty acid mixture comprising saturated fatty acids,
5 monounsaturated fatty acids and non-conjugated polyunsaturated fatty acids in the presence of ethanol to form (i) a solid fraction and (ii) a liquid fraction comprising a second fatty acid mixture, wherein the second fatty acid mixture has a higher molar ratio of total polyunsaturated fatty acids to total saturated and monounsaturated fatty acids than the first fatty acid
10 mixture;

separating the solid fraction and the liquid fraction; and

subjecting the second fatty acid mixture or a derivative or reaction product thereof to treatment with a base in the presence of a solvent, to form conjugated isomers of at least some of the polyunsaturated fatty acids.

15

The process of the invention permits the production of materials containing relatively high amounts of conjugated polyunsaturated fatty acids based on the total amount of fatty acids in the material. Preferably, the material comprises at least 90% by weight, more preferably at least 91%, even more
20 preferably at least 92%, most preferably at least 93%, such as at least 94% or at least 95%, by weight of conjugated polyunsaturated fatty acids based on total fatty acids.

The terms fatty acid, polyunsaturated fatty acids and related terms as used
25 herein refer to straight chain carboxylic acids that contain from 12 to 24 carbon atoms, preferably from 14 to 18 carbon atoms. Saturated fatty acids contain no carbon-carbon double bonds in the alkyl chain, examples are myristic acid (referred to as C14:0), palmitic acid (C16:0) and stearic acid (C18:0). Monounsaturated fatty acids contain one carbon-carbon double
30 bond in the alkyl chain, examples are oleic acid (C18:1) and elaidic acid

(C18:1). Polyunsaturated fatty acids contain two or more (preferably two) carbon-carbon double bonds in the alkyl chain, examples are linoleic acid (C18:2) and linolenic acid (C18:3).

5 The process of the invention has been found to be particularly effective when the saturated fatty acids, the monounsaturated fatty acids, and the polyunsaturated fatty acids contain 18 carbon atoms. The conjugated polyunsaturated fatty acids produced from such fatty acids are preferably conjugated linoleic acid (CLA). CLA can exist in a number of isomeric
10 forms, depending on the geometry of the two carbon-carbon double bonds, including: cis 9, trans 11; trans 10, cis 12; cis 9, cis 11; cis 10, cis 12; trans 9, trans 11; and trans 10, trans 12. The cis 9, trans 11 and trans 10, cis 12 isomers are generally the most abundant. The process of the invention can be used to produce any one or all of the isomers, and will generally result in
15 the formation of an isomer mixture in which the cis 9, trans 11 and the trans 10, cis 12 isomers are the predominant CLA isomers.

The process of the invention involves a step of treating a first fatty acid mixture comprising saturated fatty acids, monounsaturated fatty acids and
20 polyunsaturated fatty acids in the presence of ethanol to form (i) a solid fraction and (ii) a liquid fraction comprising a second fatty acid mixture. This treatment provides a liquid fraction having a higher molar ratio of total polyunsaturated fatty acids to total saturated and monounsaturated fatty acids than the first fatty acid mixture. Preferably, this treatment involves
25 treatment with urea, so that the solid fraction comprises urea, typically together with at least a proportion of the saturated fatty acids and/or the monounsaturated fatty acids. The treatment therefore results in a mixture that is enriched in polyunsaturated fatty acids relative to the first fatty acid mixture starting material. It has been surprisingly found that the use of
30 ethanol in this stage of the process, instead of methanol as taught by EP-A-

1211304, results in a higher yield of conjugated isomers after the subsequent conjugation step of the invention and, when the polyunsaturated fatty acids contain two carbon-carbon double bonds, a reduction in trans, trans isomers which can be beneficial if cis, trans isomers are required.

5

In the treatment step, the urea and the first fatty acid mixture are typically combined in liquid form. Preferably, a solution of urea in ethanol is combined with the first fatty acid mixture by adding the solution to the fatty acid mixture or vice versa. The step is generally carried out at a
10 temperature of about 10 °C to 80°C and is optionally followed by a heating step to increase the temperature to up to 80°C, if necessary. The reaction mixture is then preferably cooled to a temperature at which the urea
15 crystallises from the mixture, such as a temperature of from 0°C to 30°C. The urea crystals, which contain some saturated fatty acid and/or monounsaturated fatty acid, are separated from the mixture, for example by
filtration or centrifugation. The resulting liquid comprises a second fatty acid mixture enriched in polyunsaturated fatty acids.

The amount of urea that is used in the preferred embodiment of the process
20 is preferably sufficient to give a weight ratio of urea:ethanol of at least 1:5, preferably at least 1:4 and more preferably a weight ratio in the range of from 1:4 to 1:2. The amount of urea based on the first fatty acid mixture is preferably sufficient to give a weight ratio of urea:first fatty acid mixture of
at least 2:1, preferably at least 3:1 and more preferably a weight ratio in the
25 range of from 3:1 to 5:1.

The solvent for the process comprises ethanol. The ethanol may contain up to 20% by weight of one or more other solvents such as water and/or
methanol. Therefore, the first fatty acid mixture is typically treated in the
30 presence of a solvent comprising at least 80% by weight ethanol.

Preferably, for economic reasons, the ethanol contains from 2% to 10% by weight water.

The second fatty acid mixture that is obtained after treatment of the first fatty acid mixture is optionally subjected to further process steps (prior to treatment with the base in the conjugation step) to form a derivative or reaction product thereof. For example, the further process steps may include purification, removal of solvent from the liquid, esterification to form C₁ to C₆ alkyl esters of the fatty acids, and combinations of these steps. Generally, any derivatisation or reaction should not have the effect of significantly altering the distribution of fatty acids or, after derivatisation or reaction, fatty acid residues, in the mixture. It is particularly undesirable to reduce the amount of polyunsaturated fatty acids relative to other fatty acids in the mixture.

15

The first fatty acid mixture may be obtained by methods which are known in the art. The first fatty acid mixture will typically be derived from an animal or vegetable source. The first fatty acid mixture is preferably obtained from an oil comprising from 50% to 85% by weight based on total fatty acids of polyunsaturated fatty acids containing 18 carbon atoms. Suitable vegetable oils include safflower oil, sunflower oil, rape seed oil, cotton seed oil, soybean oil and linseed oil.

20

The first fatty acid mixture is preferably obtained by a method comprising the hydrolysis of the oil, for example with a base, such as sodium hydroxide. The process may be carried out in the presence of a solvent such as ethanol and is typically followed by acidification to form the free fatty acids. The free fatty acids may be extracted and optionally purified.

25

In the process of the invention, the second fatty acid mixture or a derivative or reaction product thereof is subjected to treatment with a base in the presence of a solvent, to form conjugated isomers of at least some of the polyunsaturated fatty acids. The second fatty acid mixture preferably
5 comprises free fatty acids. This process may be carried out according to the teaching in EP-A-0902082, the contents of which are incorporated herein by reference.

The solvent that is used in this step of the process is preferably an alcohol
10 with at least 3 carbon atoms and at least two hydroxyl groups.

A very suitable solvent is 1,3-dihydroxypropane or 1,2-dihydroxypropane (ie, propylene glycol). These solvents are foodgrade so that traces left in the products are not harmful. The reaction is preferably performed in the
15 absence of glycerol.

The base that is used in the conjugation step may be any base, but the best results are obtained with NaOH or KOH as base. Suitable concentrations for the base are greater than 0.25 mole/l of solvent, preferably 0.25-3.5 most
20 preferably 1.25-2.75 mole/l. Using higher amounts of base leads to the formation of products, wherein many isomers (in particular C18:2 trans/trans-isomers) are present.

The products are suitably isolated from the crude reaction mixture by the
25 addition of diluted acid to the soap formed until an acidic pH is achieved (preferably: pH 1 to 3), whereupon the oil is separated from the water, washed with water to pH 6 to 8 and dried. The addition of the acid results in the formation of an inorganic salt comprising the cation of the base (such as a sodium ion or potassium ion) and the anion of the acid (such as
30 chloride or sulphate). Thus, the salt formed can be, for example, potassium

sulphate. It has been found that the presence of the salt can interfere with subsequent extraction of the product. Therefore, it is preferred that the process comprises the step of removing at least a part of the salt or salts formed from the base and the acid, after the acidification step. The salt may
5 be removed by separation of the salt in solid form from the reaction mixture, when the salt has crystallised or precipitated in the reaction mixture. Preferably, the amount of salt removed is increased by cooling the reaction mixture to increase salt crystallisation or precipitation. Typically, the salt is removed with the aqueous phase by separation of the aqueous
10 phase from the non-aqueous phase, followed by cooling of the non-aqueous phase and removal of the salt thus precipitated or crystallised (e.g., by filtration).

Thus, the invention preferably comprises the step of acidifying the second
15 fatty acid mixture after treatment with the base. The acidified product is optionally purified. It is also preferred that at least a proportion of the salts formed on acidifying is removed and the resulting mixture is subsequently purified. The term "purified" refers to any increase in the content of the conjugated isomers of polyunsaturated isomers in the mixture and does not
20 imply 100% purity. Purification may be effected by removal of any remaining aqueous phase, optionally washing with water and drying, followed by a further process step such as distillation.

The conjugated polyunsaturated fatty acids that are produced in the
25 invention may be subjected to further process steps such as the formation of a mono-, di- or triglyceride of the conjugated isomers of polyunsaturated fatty acids. This step can be carried out using esterification techniques that are well-known in the art.

The product of the invention may be used as a starting material for a process in which the amount of one or more isomers (e.g., geometrical isomers) of the conjugated polyunsaturated fatty acid is enriched relative to the other isomers. A suitable process is described in WO 97/18320. Therefore, the invention contemplates a process for enriching one or more isomers of a conjugated polyunsaturated fatty acid using the product of the invention as a starting material.

In another aspect, the invention provides the use of ethanol as a solvent for the separation of polyunsaturated fatty acids from mixtures containing polyunsaturated fatty acids together with saturated and monounsaturated fatty acids by crystallisation with urea. The esterification process may result in an enrichment in one or more of the isomers, as described in WO 97/18320, the contents of which are incorporated herein by reference.

Also provided by the invention in another aspect is a product obtainable by the process of the invention. It has not previously been possible to produce fatty acid mixtures containing saturated fatty acids, monounsaturated fatty acids and conjugated isomers of polyunsaturated fatty acids, with the conjugated isomers of polyunsaturated fatty acids being present in amounts greater than 90% by weight based on total fatty acids.

Preferably, the product of the invention comprises at least 90% (more preferably at least 92%, such as at least 93% or at least 94%, even more preferably at least 95%) by weight conjugated linoleic acid, at least 43% by weight of the cis-9, trans-11 isomer of conjugated linoleic acid and at least 43% by weight of the trans-10, cis-12 isomer of conjugated linoleic acid, or the same amounts of total mono-, di- and tri- glycerides of these acids, wherein the weight ratio of the cis-9, trans-11 isomer to the trans-10, cis-12 isomer is in the range of 1.1:1 to 1:1.1 (more preferably 1.05:1 to 1:1.05).

All percentages are by weight based on total fatty acids. These products may comprise less than 1.5% by weight (more preferably less than 1.0% by weight, such as less than 0.7% by weight) of trans, trans isomers of conjugated linoleic acid or glycerides thereof. The products may comprise
5 up to 0.2% by weight saturated fatty acids and/or up to 7.5% by weight monounsaturated fatty acids, or glycerides of either fatty acids.

The invention also provides a food product, food supplement or pharmaceutical product comprising a product of the invention.

10

Products of the invention are optionally used as a blend with a complementary fat.

The blend may comprise 0.3 - 95 wt %, preferably 2-80 wt %, most
15 preferably 5-40 wt % of the product of the invention and 99.7 - 5 wt %, preferably 98-20 wt %, most preferably 95-60 wt % of a complementary fat selected from: cocoa butter, cocoa butter equivalents, palm oil or fractions thereof, palmkernel oil or fractions thereof, interesterified mixtures of said fats or fractions thereof, or liquid oils, selected from: sunflower oil, high
20 oleic sunflower oil, soybean oil, rapeseed oil, cottonseed oil, fish oil, safflower oil, high oleic safflower oil, maize oil and MCT-oils.

The food products of the invention (which term includes animal feed), may contain a fat phase, wherein the fat phase contains the product of the
25 invention. The food products are suitably selected from the group consisting of: spreads, margarines, creams, dressings, mayonnaises, ice-creams, bakery products, infant food, chocolate, confectionery, sauces, coatings, cheese and soups.

Food supplements or pharmaceutical products of the invention may be in the form of capsules or other forms, suitable for enteral or parenteral application and comprise a product of the invention.

- 5 Examples of suitable food products include those selected from the group consisting of margarines, fat continuous or water continuous or bicontinuous spreads, fat reduced spreads, confectionery products such as chocolate or chocolate coatings or chocolate fillings or bakery fillings, ice
creams, ice cream coatings, ice cream inclusions, dressings, mayonnaises,
10 cheeses, cream alternatives, dry soups, drinks, cereal bars, sauces, snack bars, dairy products, clinical nutrition products and infant formulations.

Pharmaceutical products include pharmaceutical compositions, such as in the form of tablets, pills, capsules, caplets, multiparticulates including:
15 granules, beads, pellets and micro-encapsulated particles; powders, elixirs, syrups, suspensions and solutions. Pharmaceutical compositions will comprise a pharmaceutically acceptable diluent or carrier. Pharmaceutical compositions are preferably adapted for administration parenterally (e.g., orally). Orally administrable compositions may be in solid or liquid form
20 and may take the form of tablets, powders, suspensions and syrups. Optionally, the compositions comprise one or more flavouring and/or colouring agents.

Pharmaceutically acceptable carriers suitable for use in such compositions
25 are well known in the art of pharmacy. The compositions of the invention may contain 0.1-99% by weight of conjugated fatty acid. The compositions are generally prepared in unit dosage form. Preferably the unit dosage of conjugated fatty acid is from 1mg to 1000mg (more preferably from 100mg to 750mg). The excipients used in the preparation of these compositions are
30 the excipients known in the art.

Examples of food supplements include products in the form of a soft gel or a hard capsule comprising an encapsulating material selected from the group consisting of gelatin, starch, modified starch, starch derivatives such as glucose, sucrose, lactose and fructose. The encapsulating material may optionally contain cross-linking or polymerizing agents, stabilizers, antioxidants, light absorbing agents for protecting light-sensitive fills, preservatives and the like. Preferably, the unit dosage of conjugated fatty acid in the food supplements is from 1mg to 1000mg (more preferably from 100mg to 750mg).

The following non-limiting examples illustrate the present invention. In the examples and throughout this specification, all percentages are percentages by weight unless otherwise indicated.

Examples

Example 1

27.3g NaOH was dissolved in 200ml 95% ethanol. 100g of safflower oil was added and the solution was refluxed for 2h. The resulting mixture was split with sulfuric acid, then extracted 3 times with 900ml of hexane, the hexane layers were combined and washed with distilled water until the pH was about 7, the organic layer was then evaporated using a rotary evaporator. 270g urea was dissolved in 1500ml of 95% ethanol at 30°C and fatty acids were added, then the mixture was heated to 60°C for 1 hour and then cooled to 20°C for 3 hours. The material was filtered to remove the urea crystals and the filtrate was then evaporated. 16.8g KOH was dissolved in 55ml propylene glycol in the flask, then 50g of the fatty acid mixture obtained from the filtrate after evaporation (which contains more

than 90% linoleic acid) was added. The flask was flushed with nitrogen at 150°C for 15 hours. After conjugation, the reaction mixture was placed into hot 10% sulfuric acid solution, the down layer was discarded and the up layer was washed with hot water till pH 7, and finally dried over nitrogen.

5 The conjugated linoleic acid was analyzed by GC, HPLC and the results are presented in Table 1.

Example 2 (Comparative Example)

10 The procedure of Example 1 was repeated using exactly the same conditions except that the reaction with urea was performed with methanol instead of 95% ethanol. After the reaction, the conjugated linoleic acids were analyzed and the results are shown in Table 1.

Table 1. FAME (fatty acid methyl ester) analysis

| Examples | 1 Ethanol | 2 Methanol |
|---------------|--------------|---------------|
| C14:0 | 0.0 | 0.0 |
| C16:0 | 0.1 | 0.3 |
| C16:1c | 0.1 | 0.1 |
| C18:0 | 0.0 | 0.0 |
| C18:1 c | 6.9 | 8.6 |
| C18:2 c,c | 0.4 | 0.4 |
| C18:3 c,c,c | 0.1 | 0.2 |
| CLA-9,11 c,c | 1.0 | 1.1 |
| CLA-10,12 c,c | 1.1 | 1.1 |
| CLA-11,13 c,c | 1.3 | 1.0 |
| CLA-OX | 0.0 | 0.3 |
| C18:2 t,t | 1.1 | 1.3 |
| CLA-t,t | 1.2 | 2.0 |
| CLA-9,11 c,t | 43.0 | 41.6 |
| CLA-10,12 t,c | 43.3 | 42.1 |
| SAFA | 0.1 | 0.4 |
| main CLA | 86.3 | 83.7 |
| total CLA | 91.2 | 89.1 |

- Cx:y refers to fatty acids containing x carbon atoms and y double bonds
- 5 • c means cis and t means trans
- CLA is conjugated linoleic acid; CLA-OX refers to CLA oxidation products
- in CLA m,n, m and n are the positions of the double bonds in the chain e.g., CLA-9,11 refers to the 9,11-dienoic acid

- SAFA means saturated fatty acids

The table shows the advantages of the process of the invention using ethanol instead of methanol ie, there is a higher amount of total CLA and main CLA isomers, less trans, trans isomers.

Example 3

Spreads containing triglycerides of the product of Example 1 can be formulated as follows, using the method described in WO 97/18320.

| Fat Phase | wt % |
|-------------------------------|-------------|
| Fat Blend* | 40 |
| Hymono 7804 | 0.3 |
| Colour (2% β -carotene) | <u>0.02</u> |
| Total | 40.32 |

| Aqueous Phase (to pH 5.1) | wt % |
|---------------------------|-------------|
| Water | 56.44 |
| Skimmed Milk Powder | 1.5 |
| Gelatin (270 bloom) | 1.5 |
| Potassium Sorbate | 0.15 |
| Citric Acid Powder | <u>0.07</u> |
| Total | 59.66 |

*Blend of hardstock/Sunflower oil/glycerides of the product of Example 1 (13/82/5 by weight)

Example 4

Dressings containing glycerides of the product of Example 1 can be
5 formulated as follows, using the method described in WO 97/18320.

| | wt % |
|----------------|------|
| Liquid oil* | 25.0 |
| Maltodextrin | 20.0 |
| Dried egg yolk | 0.8 |
| Xanthum gum | 0.4 |
| Vinegar | 5.0 |
| Water | 48.8 |

*Interesterified mixture of the product with sunflower oil

10 Example 5

This example relates to the conjugation of enriched safflower oil on pilot
plant scale.

15 60 kg of potassium hydroxide (50%(wt) solution, KOH) was mixed with
115 kg of propylene glycol. This mixture was heated to 70°C, while
nitrogen was bubbled through the mixture. After this, the nitrogen bubbling
was stopped and 95 kg of enriched safflower fatty acids prepared using urea
according to the present invention were added to the alkali propylene
20 glycol.

The temperature was then increased to 110°C, and the mixture was stirred at
this temperature for 2 hours. After this, the temperature was increased to

135°C and the mixture was stirred at this temperature until the C18:2c content was below 1%. This was monitored by removing samples at regular time intervals and analyzing the FAME composition by GC. In total, three batches were carried out and the average total reaction time was 82 hours.

5

The soap from each batch was split with concentrated sulphuric acid. After the conjugation reaction, the mixture was cooled down to 70°C and diluted with 250 L of hot demi-water. After this, 30 kg of concentrated sulphuric acid was added to split the soap.

10

The obtained mixture was settled and the bottom layer was drained.

The oil-phases from the three batches were put together and were washed with hot demi-water at 80°C. After first washing an emulsion layer was formed and therefore only a part of the added water could be drained. During the second washing the emulsion remains and after draining a part of the added water the oil was dried by applying vacuum.

The dried oil was distilled over short path distillation. The yield is 170 kg. Because of the emulsion there was a loss (about 40%) of product yield.

The FAME analysis of the product is given in Table 2 below.

Table 2

| | End mixture | end product |
|-------------|-------------|-------------|
| C14:0 | 0 | 0 |
| C16:0 | 0.2 | 0.2 |
| C16:1c | 0.1 | 0.1 |
| C18:0 | 0 | 0 |
| CLA t,t | 0.9 | 1.4 |
| CLA c9,c11 | 0.9 | 1 |
| CLA c10,c12 | 0.9 | 1 |
| CLA 11,13 | 1 | 0.8 |
| C18:1t | 0 | 0 |
| C18:1c | 4.9 | 4.7 |
| CLA_OX | 0.1 | 0.2 |
| C18:2 t,t | 0.6 | 0.4 |
| C18:2 c,c | 0.9 | 1.3 |
| C20:0 | 0 | 0 |
| C20:1c | 0 | 0 |
| SAFA | 0.3 | 0.2 |
| Main CLA | 89.4 | 88.8 |
| CLA c9,t11 | 44 | 43.3 |
| CLA t10,c12 | 45.5 | 45.5 |
| Total CLA | 93.2 | 93.2 |

Example 6

5

7700 kilograms of enriched safflower fatty acids were added to 9780 kilograms of propylene glycol under nitrogen blanketing in a stirred tank reactor. To this, 5120 kilograms of potassium hydroxide (50 wt-% solution, KOH) was added and heated to 110 °C under nitrogen. After removal of the water, the temperature was increased to 139 °C and stirred at this temperature until the C18:2cis content in the FAME-analysis was below 1%. The total reaction time was 42 hours.

10

After conjugation, the mixture was first cooled to 100 °C and then diluted with 25 tons of demi-water, followed by cooling to 55 °C. The diluted soap was split with 3090 kg of concentrated sulphuric acid (98 wt%). The fatty acid mixture was settled and the bottom water layer was drained. Potassium sulphate crystals, formed during splitting, were removed completely with the water phase during draining of the bottom layer. The remaining fatty acid phase was cooled to 55 °C to crystallize all remaining potassium sulphate. This was also removed to prevent emulsion formation in the following steps.

10

The fatty acids phase was heated to 95°C and washed in two steps with respectively 10 tons and 5 tons of hot demi-water (95°C). No emulsion was found in the washing steps. After washing the oil was dried for distillation.

15 The washed fatty acids was distilled by short path distillation to yield 6200 kg of product. Yield loss was reduced to 20%.

The FAME analysis of the product is shown below in Table 3.

20

Table 3

| | Product analysis |
|-------------|------------------|
| C14:0 | 0.0 |
| C16:0 | 0.2 |
| C16:1c | 0.1 |
| C18:0 | 0.1 |
| CLA t,t | 0.9 |
| CLA c9,c11 | 0.9 |
| CLA c10,c12 | 0.9 |
| CLA 11,13 | 0.8 |
| C18:1t | 0.0 |
| C18:1c | 4.8 |
| CLA_OX | 0.2 |
| C18:2 t,t | 0.6 |
| C18:2 c,c | 0.6 |
| C20:0 | 0.0 |
| C20:1c | 0.0 |
| SAFA | 0.4 |
| Main CLA | 89.9 |
| CLA c9,t11 | 44.3 |
| CLA t10,c12 | 45.6 |
| Total CLA | 93.6 |

CLAIMS

1. Process for the preparation of a material comprising conjugated isomers of a polyunsaturated fatty acid, which comprises:
 - 5 treating a first fatty acid mixture comprising saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in the presence of ethanol to form (i) a solid fraction and (ii) a liquid fraction comprising a second fatty acid mixture, wherein the second fatty acid mixture has a higher molar ratio of total polyunsaturated fatty acids to total saturated and
10 monounsaturated fatty acids than the first fatty acid mixture;
separating the solid fraction and the liquid fraction; and
subjecting the second fatty acid mixture or a derivative or reaction product thereof to treatment with a base in the presence of a solvent, to form conjugated isomers of at least some of the polyunsaturated fatty acids.
15
2. Process as claimed in Claim 1, wherein the material comprises at least 90% by weight of conjugated isomers of polyunsaturated fatty acids.
3. Process as claimed in Claim 1 or Claim 2, wherein the
20 polyunsaturated fatty acids contain from 12 to 24 carbon atoms.
4. Process as claimed in any one of the preceding claims, wherein the saturated fatty acids, the monounsaturated fatty acids, and the polyunsaturated fatty acids contain 18 carbon atoms.
25
5. Process as claimed in any one of the preceding claims, wherein the conjugated isomers are conjugated isomers of linoleic acid.

6. Process as claimed in any one of the preceding claims, wherein the first fatty acid fraction is treated with urea and the solid fraction comprises urea.
- 5 7. Process as claimed in any one of the preceding claims, wherein the first fatty acid mixture is treated in the presence of a solvent comprising at least 80% by weight ethanol.
8. Process as claimed in any one of the preceding claims, wherein the
10 second fatty acid mixture is subjected to further process steps prior to treatment with the base to form a derivative or reaction product thereof.
9. Process as claimed in Claim 9, wherein the further process steps are selected from purification, removal of solvent, esterification to form C₁ to
15 C₆ alkyl esters of the fatty acids and combinations thereof.
10. Process as claimed in any one of the preceding claims, wherein the first fatty acid mixture is obtained from an oil comprising from 50% to 85% by weight based on total fatty acids of fatty acids containing 18 carbon
20 atoms.
11. Process as claimed in any one of the preceding claims, wherein the first fatty acid mixture is obtained by a method comprising the hydrolysis of vegetable oil with a base in the presence of ethanol as solvent.
25
12. Process as claimed in Claim 11, wherein the vegetable oil is selected from the group consisting of safflower oil, sunflower oil, rape seed oil, cotton seed oil, soybean oil and linseed oil.

13. Process as claimed in any one of the preceding claims, wherein the solvent comprises an alcohol having three carbon atoms and at least two hydroxyl groups.
- 5 14. Process as claimed in any one of the preceding claims, wherein the solvent is propylene glycol.
15. Process as claimed in any one of the preceding claims, which comprises acidifying the second fatty acid mixture after treatment with a
10 base.
16. Process as claimed in Claim 15, wherein at least a proportion of the salts formed on acidifying is removed and the resulting mixture is subsequently purified.
- 15 17. Process as claimed in any one of the preceding claims, further comprising the step of forming a mono-, di- or triglyceride of the conjugated isomers polyunsaturated fatty acids.
- 20 18. Use of ethanol as a solvent for the separation of polyunsaturated fatty acids from mixtures containing polyunsaturated fatty acids together with saturated and monounsaturated fatty acids by crystallisation with urea.
19. Product obtainable by the process of any one of Claims 1 to 17.
- 25 20. Product as claimed in Claim 19 which comprises at least 90% by weight conjugated linoleic acid, at least 43% by weight of the cis-9, trans-11 isomer of conjugated linoleic acid and at least 43% by weight of the trans-10, cis-12 isomer of conjugated linoleic acid, or mono-, di- or tri-

glycerides thereof wherein the weight ratio of the cis-9, trans-11 isomer to the trans-10, cis-12 isomer is in the range of 1.1:1 to 1:1.1.

21. Product as claimed in Claim 20 comprising less than 1.5% by weight
5 of trans, trans isomers of conjugated linoleic acid.

22. Food product, food supplement or pharmaceutical product comprising a product as claimed in any one of Claims 19 to 21.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/001020

| | | |
|---|---|-----------------------|
| A. CLASSIFICATION OF SUBJECT MATTER C11C3/14 A23L1/30 A61K31/201 | | |
| According to International Patent Classification (IPC) or to both national classification and IPC | | |
| B. FIELDS SEARCHED | | |
| Minimum documentation searched (classification system followed by classification symbols) C11C A23L A61K | | |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched | | |
| Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ, FSTA, BIOSIS | | |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT | | |
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| P, X | WO 2005/014516 A (UNIVERSITE LAVAL; GARRO GALVEZ, JUAN-MIGUEL; ANGERS, PAUL; BRIAND, SAN) 17 February 2005 (2005-02-17) page 13, lines 12-23 page 15, lines 27-29 page 17, lines 27-35 | 19, 22 |
| X | ----- YANG TS, LIU TT: "Optimization of production of conjugated linoleic acid from soybean oil" J. AGRIC. FOOD. CHEM., vol. 52, 14 July 2004 (2004-07-14), pages 5079-5084, XP002330400 figure 4 page 5079, column 2, lines 3-16 | 19-22 |
| A | page 5079, column 2 - page 5080, column 2 figure 1 ----- -/-- | 1-17 |
| <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex. | | |
| * Special categories of cited documents : | | |
| 'A' document defining the general state of the art which is not considered to be of particular relevance 'E' earlier document but published on or after the international filing date 'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) 'O' document referring to an oral disclosure, use, exhibition or other means 'P' document published prior to the international filing date but later than the priority date claimed | 'T' later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention 'X' document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone 'Y' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. '&' document member of the same patent family | |
| Date of the actual completion of the international search | Date of mailing of the international search report | |
| 3 April 2006 | 08/05/2006 | |
| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | Authorized officer Couzy, F | |

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/001020

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | paragraphs [0009] - [0019] ----- | 1-17 |
| X | US 2004/015001 A1 (REANEY MARTIN J T ET AL) 22 January 2004 (2004-01-22) table 1 | 19,22 |
| A | column 3, line 54 - column 4, line 51 ----- | 1-17 |
| X | US 2004/225141 A1 (RONGIONE JOSEPH C ET AL) 11 November 2004 (2004-11-11) paragraphs [0020], [0060] - [0062], [0067] | 19-22 |
| A | paragraphs [0022], [0033] - [0042] ----- | 1-17 |
| X | US 6 479 683 B1 (ABNEY CURT ET AL) 12 November 2002 (2002-11-12) table 2 | 19,22 |
| A | column 7, lines 9-61 column 9, line 14 - column 10, line 53 ----- | 1-17 |
| X | US 2002/169332 A1 (SAEBO ASGEIR ET AL) 14 November 2002 (2002-11-14) paragraph [0020] | 19-22 |
| A | paragraphs [0013], [0025] ----- | 1-17 |
| X | US 2003/181522 A1 (STRUBE ALBERT ET AL) 25 September 2003 (2003-09-25) example 1 | 19,22 |
| A | paragraphs [0018] - [0020] paragraphs [0009] - [0016] ----- | 1-17 |
| X | US 4 792 418 A (RUBIN ET AL) 20 December 1988 (1988-12-20) column 6, lines 40-48 | 18 |
| A | column 4, lines 23-58 column 5, line 35 - column 7, line 18 ----- | 1-17 |
| A | EP 1 211 304 A (SEPU FINE CHEM CO., LTD) 5 June 2002 (2002-06-05) cited in the application paragraphs [0009], [0012], [0013], [0018] - [0020], [0025], [0029] example 1 ----- | 1-17 |

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2006/001020

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-17, 19-22

Process for the preparation of conjugated isomers of polyunsaturated fatty acids, and derived products

2. claim: 18

Use of a specific solvent to accomplish a step of a process for the fractionation of fatty acids

INTERNATIONAL SEARCH REPORT

Information on patent family members

| |
|---|
| International application No PCT/EP2006/001020 |
|---|

| Patent document cited in search report | A | Publication date | Patent family member(s) | Publication date |
|--|----|------------------|--|--|
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| EP 0902082 | A | 17-03-1999 | NONE | |
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