

TEXTURED FOOD PRODUCT MADE FROM MICROALGAE

FIELD OF INVENTION

5 The subject matter of the invention relates to the production of a novel food product made from at least one microalgae. It can be used as an intermediate for manufacturing a more complex product intended either for human food or for veterinary food. The invention also relates to the uses of said food product made from at least one microalgae. The invention also relates to a method for producing said food product made from at least one microalgae.

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PRIOR ART

Spirulina is a cyanobacterium of great nutritional and ecological interest. It grows anywhere with little energy, little land area and little water. It is consumed worldwide as a natural food supplement. Spirulina is naturally rich in protein (65 to 70% of its dry weight), which is highly
15 bioavailable and contains all the essential amino acids, making it a relevant alternative to animal protein.

However, spirulina is currently consumed in the form of an unappetising dry powder that is difficult to incorporate into recipes due to its strong taste, smell and green colour.

The industry has therefore not yet found a suitable way to promote spirulina protein as an
20 alternative to meat in human and veterinary nutrition.

BRIEF OVERVIEW

A first aim of the invention is to provide a new textured food product based on at least one gelled microalgae and/or at least one of its gelled derivatives with high nutritional value. A
25 second aim of the invention is to propose a process for producing said new textured food product based on at least one gelled microalgae and/or at least one of its gelled derivatives. Another aim of the invention is to use the new textured food product based on at least one gelled microalgae and/or at least one of its gelled derivatives as an intermediate product that can be used in the manufacture of other products.

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DETAILED DESCRIPTION

According to a first aspect of the invention, the subject matter of the invention relates to a textured product comprising:

- at least 50% by weight of at least one gelled microalgae and/or at least one of
35 its gelled derivatives, relative to the total weight of said textured product; and
- at least 5% by weight of oil relative to the total weight of said textured product,

said textured product having a moisture content from 13% to 71% and being in the form of grains with an average particle size from 2 mm to 10.5 mm, said textured product (*set of grains*) having the following properties:

- 5 ▪ a hardness from 2.5 N to 369 N in a texture analysis using a texturometer;
- a resilience from 0.016 to 0.46 in a texture analysis using a texturometer; and
- a cohesion from 0.090 to 0.76 in a texture analysis using a texturometer.

According to another embodiment, the subject matter of the invention relates to the textured product as described above comprising:

- 10 ▪ at least 50% by weight of at least one gelled microalgae and/or at least one of its gelled derivatives, relative to the total weight of said textured product; and
 - at least 5% by weight of oil relative to the total weight of said textured product,
- said textured product having a moisture content from 13% to 71% and being in the form of grains with an average particle size from 2 mm to 10.5 mm, said textured product (*set of grains*) having the following properties:
- 15 ▪ a hardness from 2.8 N to 369 N in a texture analysis using a texturometer;
 - a resilience from 0.016 to 0.30 in a texture analysis using a texturometer; and
 - a cohesion from 0.090 to 0.67 in a texture analysis using a texturometer.

The expression "textured product" means the product of the invention as having texture characteristics that can be measured in a texture analysis using a texturometer (Figure 1), which will be detailed later in the description. This characteristic texture of the product of the invention developed by the inventors surprisingly makes it possible to use microalgae proteins, particularly spirulina, as an alternative to meat, but not only that. Indeed, and unexpectedly, the product of the invention can be used for other applications such as animal feed or as an ingredient in the manufacture of more complex products.

25 The expression "gelled microalgae" means the form taken by the raw material (*i.e.* microalgae) after the process of the invention has been carried out. Advantageously, the raw material of the invention is selected from: spirulina (e.g. *Arthrospira platensis* or *Spirulina platensis*, *Arthrospira fusiformis*, *Arthrospira maxima*, or *Arthrospira indica*), chlorella (e.g. *Chlorella vulgaris*, *Auxenochlorella protothecoides*, *Auxenochlorella pyrenoidosa*, or *Chlorella sorokiniana Shihira*), klamath (e.g. *Aphanizomenon flosaquae*) and mixtures thereof, and/or at least one of its derivatives. "Mixtures thereof" means a spirulina/chlorella mixture, a spirulina/klamath mixture, a chlorella/klamath mixture, and a spirulina/chlorella/klamath mixture. It should be noted that within the same microalgae family, a mixture of species may also be used. For example, for spirulina, this could be a mixture of *A. platensis* and *A. fusiformis*.

40 The term "gelled" means the fact that, after undergoing the process of the invention, the microalgae take the form of a gel, *i.e.* a viscoelastic material wherein a continuous liquid phase (often the majority or even the vast majority by mass) is "trapped" by a three-dimensional elastic network. This network is percolating, *i.e.* the objects that constitute it are connected to each other from one end of the gel to the other, and it can be formed of particles, polymer chains, proteins, *etc.* In a gel, it is this network that is responsible for the elasticity of the material, the elasticity of the liquid phase being negligible in comparison.

The expression "at least one gelled microalgae" means the possibility that the textured product as described above may comprise several different gelled microalgae. There may be 2, 3 or 4

of these. Advantageously, there are 2 (for example: a spirulina/chlorella mixture, a spirulina/klamath mixture or a chlorella/klamath mixture).

The expression "one of its gelled derivatives" means the form taken by a derivative of the raw material after the process of the invention has been carried out. Advantageously, this derivative of the raw material is a co-product resulting from the industrial processing of at least one microalgae and, in particular, it is a co-product of pigment extraction such as phycocyanin.

The expression "at least one of its gelled derivatives" means the possibility that the textured product as described above may comprise several different gelled derivatives. There may be 2, 3 or 4 of these.

The expression "at least one gelled microalgae and/or at least one of its gelled derivatives," means the fact that the textured product as described above comprises one or the other, or both. That is to say, according to another embodiment, the subject matter of the invention relates to the textured product as described above comprising at least 50% by weight of at least one gelled microalgae relative to the total weight of said textured product, as it relates to: the textured product as described above comprising at least 50% by weight of at least one derivative of a gelled microalgae relative to the total weight of said textured product; or the textured product as described above comprising at least 50% by weight of at least one gelled microalgae and at least one of its gelled derivatives, relative to the total weight of said textured product.

The expression "at least 50% by mass of at least one gelled microalgae and/or at least one of its gelled derivatives relative to the total mass of said textured product" means the possibility that the textured product as described above comprises 50% or more by mass of at least one gelled microalgae and at least one of its gelled derivatives relative to the total mass of said textured product. This may therefore be at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90% or at least 95%. Advantageously, the textured product as described above comprises from 50% to 80% by mass of at least one gelled microalgae and/or at least one of its gelled derivatives relative to the total mass of said textured product. It should be noted that "from 50% to 80%" also means the ranges from 50% to 60%, from 50% to 70%, from 60% to 80%, from 70% to 80%, or from 60% to 70%.

The expression "at least 5% by mass of oil relative to the total mass of said textured product" means the possibility that the textured product as described above may comprise 5% or more by mass of oil relative to the total mass of said textured product. This may therefore be at least 10%, at least 20%, at least 30%, at least 40% or at least 50%. Advantageously, the textured product as described above comprises from 5% to 50% by mass of oil relative to the total mass of said textured product. It should be noted that "5% to 50%" also means the ranges from 5% to 10%, from 5% to 20%, from 5% to 30%, from 5% to 40%, from 10% to 50%, from 20% to 50%, from 30% to 50%, from 40% to 50%, from 10% to 40%, or from 20% to 30%.

The expression "moisture content" means the amount of water in the textured product as described above. It is measured using a balance before and after evaporation of the water and comes in particular from the at least one gelled microalgae and/or the at least one gelled derivative thereof. As mentioned above, this ranges from 13% to 71%. It may also range from 13% to 20%, from 14% to 36%, from 14% to 55%, from 14% to 70%, from 30% to 71%, or from 35% to 55%.

The expression "in the form of grains" means the shape of the textured product as described above, which is in the form of grains. Although these grains are irregular in shape, photographic analysis can be used to determine their equivalent diameter and thus measure their particle size. This equivalent diameter corresponds to the assimilation of the measured surface area of a grain in the photograph to that of a disc, and it has been measured that the average particle size (arithmetic mean of the equivalent diameters) of each of the grains in the product is from 2 mm to 10.5 mm. Advantageously, this can also range from 4 mm to 10.5 mm or from 6.5 mm to 8.3 mm.

Previously, it was mentioned that the product of the invention has texture characteristics that can be measured in a texture analysis using a texturometer. As it is in the form of grains, it is understood that it is these grains (which constitute the textured product of the invention) that have the following properties:

- a hardness from 2.5 N to 369 N, in particular from 2.8 N to 369 N, in a texture analysis using a texturometer;
- a resilience from 0.016 to 0.46, in particular from 0.016 to 0.30, in a texture analysis using a texturometer; and
- a cohesion from 0.090 to 0.76, in particular from 0.090 to 0.67, in a texture analysis using a texturometer.

Hardness here characterises the mechanical resistance to compression of the textured product as described above. This is measured using a texturometer and corresponds to the maximum force that occurs during the first compression. In particular, it is measured with the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular without excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The hardness of the grains was measured to be from 2.5 N to 369 N, in particular from 2.8 N to 369 N. Advantageously, it can also be from 9.4 N to 150 N or from 11.4 N to 150 N.

A resilience here characterises the ability of the textured product described above to return to its original size/shape after compression. This is measured using a texturometer and is measured upon removal of the first compression, before the start of the waiting period. In particular, it is measured using the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The resilience of the grains was measured to be from 0.016 to 0.46, in particular from 0.016 to 0.30. Advantageously, it can range from 0.016 to 0.25, from 0.016 to 0.23, from 0.022 to 0.20 or from 0.09 to 0.19.

A cohesion here characterises the ability of the textured product as described above to resist a second deformation, relative to its ability to resist a first deformation. This is measured using a texturometer. In particular, it is measured using the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s;

Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The grain cohesion was measured to be from 0.090 to 0.76, in particular from 0.090 to 0.67. Advantageously, it can be from 0.145 to 0.60 or from 0.30 to 0.57.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having an elasticity ranging from 0.20 to 1 in a texture analysis using a texturometer.

An elasticity here characterises the speed at which the textured product described above returns to its undeformed state after deformation when the deforming force is removed. This is measured using a texturometer and corresponds to the elastic recovery measured during the downward stroke of the second compression. In particular, it is measured using the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The elasticity of the grains was measured to be from 0.20 to 1. Advantageously, it can be from 0.29 to 0.99 or from 0.54 to 0.75.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having a chewiness ranging from 0.23 N to 110 N in a texture analysis using a texturometer.

A chewiness here characterises the energy required to break down the textured product as described above. This is measured using a texturometer. In particular, it is measured with the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The chewiness of the grains was measured to be from 0.23 N to 110 N. Advantageously, it can be from 2.7 N to 42 N or from 3 N to 10.2 N.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having a gumminess ranging from 1 N to 111 N in a texture analysis using a texturometer.

Gumminess here characterises the energy required to break down a semi-solid product such as the textured product described above. It is measured using a texturometer. In particular, it is measured using the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The gumminess of the grains was measured to be from 1 N to 111 N. Advantageously, it can be from 5 N to 57 N or from 5 N to 10.3 N.

In view of the above, it is therefore understood that, according to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having:

- an elasticity ranging from 0.20 to 1 in a texture analysis using a texturometer; and/or

- a chewiness from 0.23 N to 110 N in a texture analysis using a texturometer; and/or
- a gumminess from 1 N to 111 N in a texture analysis using a texturometer.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having:

- an elasticity from 0.20 to 1 in a texture analysis using a texturometer; and
- a chewiness from 0.23 N to 110 N in a texture analysis using a texturometer.

In another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having:

- an elasticity from 0.20 to 1 in a texture analysis using a texturometer; and
- a gumminess from 1 N to 111 N in a texture analysis using a texturometer.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having:

- a chewiness from 0.23 N to 110 N in a texture analysis using a texturometer; and
- a gumminess ranging from 1 N to 111 N in a texture analysis using a texturometer.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having:

- an elasticity from 0.20 to 1 in a texture analysis using a texturometer;
- a chewiness ranging from 0.23 N to 110 N in a texture analysis using a texturometer; and
- a gumminess from 1 N to 111 N in a texture analysis using a texturometer.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having an adhesiveness from -1.7 N.sec to 10.5 N.sec in a texture analysis using a texturometer. According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further having an adhesiveness from -0.03 N.sec to 10.5 N.sec in a texture analysis using a texturometer.

An adhesiveness here characterises the ability of the textured product as described above to stick. It is measured using a texturometer and is measured by the force required to remove the module after the first compression. In particular, it is measured with the Stable Micro Systems texturometer - model TA-HD plus coupled with a 5 kg load cell and a 20 mm probe placed approximately 1 cm above the textured product as described above (5 g; in particular free of excess oil), with the T.A/T.A of the software being set as follows: Pre-test speed: 1 mm/s; Test speed: 2 mm/s; Post-test speed: 1 mm/s; Target mode: Distance; Distance: 10 mm and Time: 2 seconds. The adhesiveness of the grains was measured to be from -1.7 N.sec to 10.5 N.sec, in particular from -0.03 N.sec to 10.5 N.sec. Advantageously, this can range from 0.0010 N.sec to 10.5 N.sec, from 0.0010 N.sec to 10.5 N.sec or from 0.0017 N.sec to 2.25 N.sec.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 30% to 71% and the following texture properties:

- a hardness from 6.09 N to 368.66 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.59 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 2.01 N to 10.12 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.13 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 30% to 40% (in particular from 35% to 37%) and the following texture properties:

- a hardness from 6.09 N to 368.66 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.05 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity ranging from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 2.01 N to 9.19 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.14 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*),

having in particular an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 30% to 40% (in particular from 35% to 37%) and the following texture properties:

- a hardness from 6.09 N to 18.08 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.05 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 2.01 N to 9.19 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.14 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 30% to 71% (in particular from 35% to 55%) and the following texture properties:

- a hardness of 38.844 ± 56.215 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness of 0.589 ± 1.71 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity of 0.549 ± 0.267 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion of 0.43 ± 0.127 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness of 10.121 ± 15.74 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and

- a resilience of 0.131 ± 0.047 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 40% to 45% (in particular 42%) and the following texture properties:

- a hardness of 13.112 ± 7.545 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness of -0.03 ± 0.027 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity of 0.612 ± 0.098 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion of 0.642 ± 0.04 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness of 5.085 ± 2.803 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience of 0.242 ± 0.049 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a moisture content from 13% to 25% (in particular from 13% to 14%) and the following texture properties:

- a hardness from 6.15 N to 16.46 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.01 N.sec to 4.77 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.49 to 0.98 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.10 to 0.55 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 6.33 N to 9.76 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);

- a chewiness from 3.79 N to 5.17 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.02 to 0.17 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size from 6 mm to 7 mm (in particular from 6.5 mm to 6.6 mm).

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product having a pH from 6.5 to 10. By "pH from 6.5 to 10", it is understood that the pH of the textured product of the invention may be from 6.5 to 7.0; from 7.0 to 7.5; from 7.5 to 8.0; from 8.0 to 8.5; from 8.5 to 9.0; from 9.0 to 9.5; from 9.5 to 10; from 6.5 to 7.5; from 7.5 to 8.5; from 8.5 to 9.5; from 7.0 to 9.0; from 7.0 to 8.0, or from 6.5 to 9.5. This also means that the pH of the textured product of the invention may be 6.5; 6.6; 6.7; 6.8; 6.9; 7.0; 7.1; 7.2; 7.3; 7.4; 7.5; 7.6; 7.7; 7.8; 7.9; 8.0; 8.1; 8.2; 8.3; 8.4; 8.5; 8.6; 8.7; 8.8; 8.9; 9.0; 9.1; 9.2; 9.3; 9.4; 9.5; 9.6; 9.7; 9.8; 9.9 or 10.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product comprising a gelled matrix wherein there are cell clusters of said at least one gelled microalgae and/or said at least one of its gelled derivatives, and inclusions of said oil in the form of droplets.

The expression "cell cluster" means a grouping of cells, which may sometimes take the form of a filament. This is particularly the case when the raw material is spirulina. In particular, the invention therefore relates to the textured product as described above, said textured product comprising a gelled matrix wherein filaments of said at least one gelled microalgae and/or said at least one of its gelled derivatives are found.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said at least one gelled microalgae being selected from: spirulina (e.g. *A. platensis* or *S. platensis*, *A. fusiformis*, *A. maxima*, or *A. indica*), chlorella (e.g., *C. vulgaris*, *A. protothecoides*, *A. pyrenoidosa*, or *C. sorokiniana Shihira*), klamath (e.g., *A. flosaquae*) and mixtures thereof; and/or at least one of its gelled derivatives, being a co-product resulting from the industrial processing of at least one microalgae (*in particular chosen from: spirulina, chlorella, klamath and mixtures thereof*), in particular at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said at least one gelled microalgae being selected from: spirulina, chlorella, klamath and mixtures thereof. In particular, the subject matter of the invention relates to the textured product as described above, said at least one gelled microalgae being gelled spirulina.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said at least one of its gelled derivatives, being a co-product resulting from the industrial processing of at least one microalgae, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin. In

particular, the subject matter of the invention relates to the textured product as described above, said at least one of its gelled derivatives being a co-product resulting from the industrial processing of spirulina, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

- 5 According to another embodiment, the subject matter of the invention relates to the textured product as described above, said at least one gelled microalgae being selected from: spirulina, chlorella, klamath and mixtures thereof;
and said at least one of its gelled derivatives, being a co-product from the industrial processing of at least one microalgae, in particular said at least one of its derivatives being a co-product
10 from the extraction of a pigment such as phycocyanin.

- According to another embodiment, the subject matter of the invention relates to the textured product as described above, said at least one gelled microalgae being gelled spirulina and said at least one of its gelled derivatives, being a co-product resulting from the industrial processing of spirulina, in particular said at least one of its derivatives being a co-product of
15 pigment extraction such as phycocyanin.

- According to another embodiment, the subject matter of the invention relates to the textured product as described above, wherein said at least one gelled microalgae and said at least one of its gelled derivatives are mixed together, the mass ratio [*gelled microalgae: one of its gelled derivatives*] being from [1:5] to [5:1]. It may therefore be [1:5], [1.5:4.5], [2:4], [2.5:3.5], [3:3],
20 [3.5:2.5], [4:2], [4.5:1.5], [5:1] or [1:1].

- According to another embodiment, the subject matter of the invention relates to the textured product as described above, said oil being a vegetable oil selected in particular from: sunflower oil, high oleic sunflower oil, deodorised sunflower oil, frying sunflower oil, virgin coconut oil, deodorised virgin coconut oil, rapeseed oil, olive oil, peanut oil, linseed oil and mixtures thereof.
25 In particular, the subject matter of the invention relates to the textured product as described above, said oil being a vegetable oil selected from: sunflower oil, high oleic sunflower oil, deodorised sunflower oil, frying sunflower oil, virgin coconut oil, deodorised virgin coconut oil, rapeseed oil, olive oil, peanut oil, linseed oil and mixtures thereof. The expression "mixtures thereof" means mixtures of 2, 3, 4, 5, 6, 7, 8, 9 and 10 oils. Advantageously, the subject matter
30 of the invention relates to the textured product as described above, said oil being a mixture of rapeseed oil (in particular 49%), sunflower oil (in particular 41%), linseed oil (in particular 6%) and sunflower oil with a high oleic acid content (in particular 4%).

- According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight,
35 relative to the total weight of said textured product, of a flour selected in particular from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;
and/or a fibre selected in particular from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof; and/or
40 a starch, in particular potato starch.

The expression "at least 5% by weight relative to the total weight of said textured product of a flour [...]; and/or a fibre [...]; and/or a starch [...]" means the possibility of introducing into the product of the invention (*via* its manufacturing process) a flour, a fibre, a starch, a mixture of a

flour and a fibre, a mixture of a flour and a starch, a mixture of a fibre and a starch, or a mixture of a flour, a fibre and a starch. This addition may correspond to at least 5% by weight relative to the total weight of the textured product as described above. That is to say, it may be 5% or more, such as at least 10%, at least 15%, or at least 20%. Advantageously, the textured product as described above comprises from 5% to 20% by mass of a flour and/or fibre and/or starch relative to the total mass of said textured product. It should be noted that "from 5% to 20%" also refers from 5% to 10%, from 5% to 15%, from 10% to 15%, or from 10% to 20%.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof. "Mixtures thereof" means mixtures of 2, 3, 4, 5, 6, 7 and 8 flours.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof. The expression "mixtures thereof" means mixtures of 2, 3 and 4 fibres. Advantageously, this fibre is oat bran fibre.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of potato starch.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;
and a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;
and potato starch.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof;
and potato starch.

According to another embodiment, the subject matter of the invention relates to the textured product as described above, said textured product further comprising at least 5% by weight, relative to the total weight of said textured product, of a flour selected from: wheat flour, coconut

flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;

a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof;

5 and potato starch.

According to a second aspect, the subject matter of the invention relates to a process for producing the textured product described above from a raw material, said process comprising at least the following steps:

- 10 i) gelling said raw material in an oil to obtain a gelled raw material in the form of grains;
- ii) recovering said gelled raw material in the form of grains; and
- iii) cooling said gelled raw material in the form of grains to obtain the textured product as described above.

15 Step i) of gelation refers to a process resulting in the formation of a gel, during the transition from the fluid or liquid state of a raw material to an almost solid state called the gel state. In the invention, this raw material comprises at least one microalgae and/or at least one of its derivatives. Advantageously, this raw material is chosen from: spirulina (e.g. *A. platensis* or *S. platensis*, *A. fusiformis*, *A. maxima*, or *A. indica*), chlorella (e.g. *C. vulgaris*, *A. protothecoides*,

20 *A. pyrenoidosa*, or *C. sorokiniana Shihira*), klamath (e.g. *A. flosaquae*) and mixtures thereof, and/or derivatives thereof.

According to another embodiment, the subject matter of the invention therefore relates to the process described above for preparing the textured product described above, said process comprising at least the following steps:

- 25 i) gelling at a temperature from 120°C to 160°C (in particular from 120°C to 140°C) for a period from 5 minutes to 10 minutes of at least one microalgae and/or at least one of its derivatives in an oil previously heated at a temperature from 120°C to 160°C (in particular from 120°C to 140°C), said gelation being carried out under agitation using non-cutting means, to obtain at least one gelled
- 30 microalgae in the form of grains and/or at least one of its gelled derivatives, in the form of grains;
- ii) recovering said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains;
- iii) optionally, removing excess oil present in said at least one gelled microalgae in
- 35 the form of grains and/or said at least one of its gelled derivatives in the form of grains to obtain at least one gelled microalgae optionally free of excess oil in the form of grains and/or at least one of its gelled derivatives, optionally free of excess oil, in the form of grains; and
- iv) cooling said at least one gelled microalgae optionally free of excess oil in the
- 40 form of grains and/or at least one of its gelled derivatives, optionally free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or equal to 4°C (*in particular from -20°C to 4°C*) and obtaining the aforementioned textured product as described above.

The expression "temperature ranging from 120°C to 160°C (in particular ranging from 120°C to 140°C)" means the fact that the temperature of the preheated oil and that of gelatinisation may be 120°C or 160°C, as it may be at a temperature of 125°C, 130°C, 135°C, 140°C, 145°C, 150°C or 155°C. The possible temperature ranges for implementing the process of the invention also include temperatures ranging from 120°C to 130°C, from 120°C to 135°C, from 120°C to 140°C, from 120°C to 145°C, from 120°C to 150°C, from 120°C to 155°C, from 125°C to 160°C, from 130°C to 160°C, from 135°C to 160°C, from 140°C to 160°C, from 145°C to 160°C, from 150°C to 160°C, from 155°C to 160°C, from 130°C to 150°C, from 120°C to 125°C, from 125°C to 130°C, from 130°C to 135°C, from 135°C to 140°C, from 140°C to 145°C, from 145°C to 150°C or from 150°C to 155°C. Advantageously, the temperature is from 120°C to 140°C or is 136°C.

The expression "duration from 5 min to 10 min" means that, in order to achieve gelation of at least one microalgae and/or at least one of its derivatives, step i) may last 5 min, 8 minutes or 10 minutes, as it may last 5.25 minutes, 5.5 minutes, 5.75 minutes, 6 minutes, 6.25 minutes, 6.5 minutes, 6.75 minutes, 7 minutes, 7.25 minutes, 7.5 minutes, 7.75 minutes, 8.25 minutes, 8.5 minutes, 8.75 minutes, 9 minutes, 9.25 minutes, 9.5 minutes or 9.75 minutes. Among the possible ranges of duration for implementing the process of the invention are durations ranging from 5 min to 5.25 min, from 5.25 min to 5.5 min, from 5.5 min to 5.75 min, from 5.75 min to 6 min, from 6 min to 6.25 min, from 6.25 min to 6.5 min, from 6.5 min to 6.75 min, from 6.75 min to 7 min, from 7 min to 7.25 min, from 7.25 min to 7.5 min, from 7.5 min to 7.75 min, from 7.75 min to 8 min, from 8 minutes to 8.25 minutes, from 8.25 minutes to 8.5 minutes, from 8.5 minutes to 8.75 minutes, from 8.75 minutes to 9 minutes, from 9 min to 9.25 min, from 9.25 min to 9.5 min, from 9.5 min to 9.75 min, from 9.75 min to 10 min, from 5 min to 6 min, from 5 min to 7 min, from 5 min to 8 min, from 5 min to 9 min, from 6 min to 7 min, from 6 min to 8 min, from 6 min to 9 min, from 6 min to 10 min, from 7 min to 8 min, from 7 min to 9 min, from 7 min to 10 min, from 8 min to 9 min, from 8 min to 10 min or from 9 min to 10 min. Advantageously, the duration is 7.25 min.

The expression "under agitation using non-cutting means" means the fact that step (i) is carried out using methods that do not involve the use of cutting objects. In other words, it involves mixing or stirring said at least one microalgae and/or said at least one of its derivatives in a preheated oil using elements that are not likely to cut or slice the material. "Non-cutting means" may include stirrers, blades, or other devices designed to mix without causing physical damage to the material. It may also involve the use of blades, but with a reverse rotation direction compared to the usual one, so that the cutting edge is ineffective. If the invention is implemented using a Robot Cook® (sold by Robot Coupe®), stirring is carried out using the blades supplied, rotating them in an anti-clockwise direction. It should be noted that, advantageously, the process of the invention is carried out with a Robot Cook® (sold by Robot Coupe®), in particular the model referenced RR43000R).

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein the aforementioned stirring in step i) is carried out at a speed from 100 rpm to 200 rpm. If sharp blades are used, the rotation speed is reversed so that the cutting edge is ineffective and the blades act like paddles. The expression "speed ranging from 100 rpm to 200 rpm" means the possibility that the speed may be 100 rpm, 125 rpm, 150 rpm, 175 rpm or 200 rpm. The stirring speed (clockwise or counter-clockwise depending on the stirring means used) can therefore also range from 100 rpm to 125 rpm, 125 rpm to 150 rpm,

150 rpm to 175 rpm, or 175 rpm to 200 rpm. Advantageously, this is from 125 rpm to 175 rpm. For all intents and purposes, it should be noted that a speed ranging from -100 rpm to -200 rpm (preferably from -125 rpm to -175 rpm) may be mentioned when referring to counterclockwise or reverse rotation relative to the usual rotation of the stirring means used.

- 5 According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae is selected from: spirulina (e.g. *A. platensis* or *S. platensis*, *A. fusiformis*, *A. maxima*, or *A. indica*), chlorella (e.g., *C. vulgaris*, *A. protothecoides*, *A. pyrenoidosa*, or *C. sorokiniana Shihira*), klamath (e.g., *A. flosaquae*) and mixtures thereof;
- 10 and/or said at least one of its derivatives is a co-product resulting from the industrial processing of at least one microalgae (*in particular chosen from: spirulina, chlorella, klamath and mixtures thereof*), in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

- 15 According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae is selected from: spirulina, chlorella, klamath and mixtures thereof. In particular, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae is spirulina.

- 20 According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one of its derivatives is a co-product resulting from the industrial processing of at least one microalgae, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin. In particular, the subject matter of the invention relates to the process as described above, wherein said at least one of its derivatives is a co-product resulting from the industrial processing of spirulina, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.
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- According to another embodiment, the subject matter of the invention relates to the process described above, wherein said at least one microalgae is selected from: spirulina, chlorella, klamath and mixtures thereof;
- 30 and said at least one of its derivatives is a co-product resulting from the industrial processing of at least one microalgae, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

- 35 According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae is spirulina and said at least one of its derivatives is a co-product resulting from the industrial processing of spirulina, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

- 40 According to another embodiment, the subject matter of the invention relates to the process described above, wherein said at least one microalgae and said at least one of its derivatives are mixed, the mass ratio [*microalgae: one of its derivatives*] being from [1:5] to [5:1]. The latter may therefore be [1:5], [1.5:4.5], [2:4], [2.5:3.5], [3:3], [3.5:2.5], [4:2], [4.5:1.5] or [5:1].

According to another embodiment, the subject matter of the invention relates to the process described above, wherein said oil is a vegetable oil selected in particular from: sunflower oil,

high oleic sunflower oil, deodorised sunflower oil, frying sunflower oil, virgin coconut oil, deodorised virgin coconut oil, rapeseed oil, olive oil, peanut oil, linseed oil and mixtures thereof. In particular, the subject matter of the invention relates to the process described above, wherein said oil is a vegetable oil selected from: sunflower oil, high oleic sunflower oil, deodorised sunflower oil, frying sunflower oil, virgin coconut oil, deodorised virgin coconut oil, rapeseed oil, olive oil, peanut oil, linseed oil and mixtures thereof. Advantageously, the subject matter of the invention relates to the process described above, wherein said oil is a mixture of rapeseed oil (in particular 49%), sunflower oil (in particular 41%), linseed oil (in particular 6%) and high oleic sunflower oil (in particular 4%).

10 According to another embodiment, the subject matter of the invention relates to the process described above for preparing the textured product described above, said process comprising at least the following steps:

- 15 i) gelling at a temperature of 136°C for a period of 6 minutes 20 seconds of at least one microalgae (in particular spirulina) and/or at least one of its derivatives in an oil previously heated at a temperature of 136°C, said gelation being carried out with stirring using non-cutting means at a speed of 100 rpm (clockwise or anticlockwise depending on the equipment used), to obtain at least one gelled microalgae in the form of grains and/or at least one of its gelled derivatives in the form of grains;
- 20 ii) recovering said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains;
- 25 iii) optionally, removing excess oil present in said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains to obtain at least one gelled microalgae optionally free of excess oil in the form of grains and/or at least one of its gelled derivatives optionally free of excess oil in the form of grains; and
- 30 iv) cooling said at least one gelled microalgae optionally free of excess oil in the form of grains and/or at least one of its gelled derivatives optionally free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or equal to 4°C (*in particular from -20°C to 4°C*) and obtaining the aforementioned textured product as described above.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;

35 and/or a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof;

and/or a starch, in particular potato starch.

To carry out this step, it should be noted that it is advantageous to first prepare a mixture of thawed microalgae and/or at least one of its thawed derivatives with a flour and/or fibre and/or starch, said mixture then being introduced into oil previously heated at temperature from 120°C to 160°C. To make this mixture, a KitchenAid® food processor (artisan model reference 5KSM125EER) sold by KitchenAid® can be used. It should be noted that the quantity of flour and/or fibre and/or starch is at least 5% (in particular from 5% to 20%; or represents 5%, 7%, 12% or 20%) by mass of flour and/or fibre and/or starch relative to the total mass of the thawed

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microalgae mixture and/or at least one of its thawed derivatives with flour and/or fibre and/or starch.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof.

According to another embodiment, the subject matter of the invention relates to the process described above, wherein step i) further comprises adding a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof. Advantageously, this fibre is oat bran fibre.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a starch, in particular potato starch. When starch is added, it is possible, but not necessary, to carry out a preliminary heat treatment step (e.g. approximately at 90°C for approximately 5 minutes, or a temperature from 89°C to 95°C for a period from 4.5 to 6 minutes) to the mixture of thawed microalgae and/or at least one of its thawed derivatives with a starch.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof; and a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof; and a starch, in particular potato starch.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof; and a starch, in particular potato starch.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step i) further comprises adding a flour selected from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof; a fibre selected from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof; and a starch, in particular potato starch.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein a preliminary step of freezing (at a temperature below 0°C, in particular from -20°C to -4°C) and/or thawing (at a temperature above 0°C, in particular from

4°C to 25°C) of said at least one microalgae and/or said at least one of its derivatives is carried out before step i) to obtain at least one frozen and/or thawed microalgae and/or at least one of its frozen and/or thawed derivatives. As indicated by the process described above, said frozen and/or thawed microalgae and/or said at least one of its frozen and/or thawed derivatives is/are then immersed in an oil previously heated at a temperature from 120°C to 160°C, *etc.*

In particular, the subject matter of the invention relates to the process described above, wherein a preliminary freezing step (at a temperature below 0°C, in particular from -20°C to -4°C) of said at least one microalgae and/or said at least one of its derivatives is carried out before step i) to obtain at least one frozen microalgae and/or said at least one of its derivatives, frozen. Advantageously, this freezing step allows the raw material (*e.g.* microalgae biomass) to be preserved untreated over the long term and facilitates its transport.

In particular, the subject matter of the invention relates to the process as described above, wherein a preliminary step of thawing (at a temperature above 0°C, in particular from 4°C to 25°C) said at least one microalgae and/or said at least one of its derivatives is carried out before step i) to obtain at least one thawed microalgae and/or said at least one of its derivatives, thawed. Advantageously, this thawing step allows for better temperature transfer, which can reduce the duration of the invention's process.

In particular, the invention also relates to the process as described above, wherein a preliminary step of freezing (temperature below 0°C, in particular from -20°C to -4°C) and thawing (at a temperature above 0°C, in particular from 4°C to 25°C) of said at least one microalgae and/or said at least one of its derivatives is carried out before step i) to obtain at least one frozen and thawed microalgae and/or said at least one of its derivatives, frozen and thawed.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein step iii) is not optional. In other words, in this case, the subject matter of the invention relates to the process as described above, said process comprising at least the steps:

- i) gelling at a temperature from 120°C to 160°C for a period from 5 minutes to 10 minutes of at least one microalgae and/or at least one of its derivatives in an oil previously heated at a temperature from 120°C to 160°C, said gelation being carried out under agitation using non-cutting means, to obtain at least one gelled microalgae in the form of grains and/or at least one of its gelled derivatives, in the form of grains;
- ii) recovering said at least one gelled microalgae in the form of grains and/or said at least one of its derivatives gelled in the form of grains;
- iii) removing excess oil present in said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains to obtain at least one gelled microalgae and free of excess oil in the form of grains and/or at least one of its gelled derivatives and free of excess oil in the form of grains; and
- iv) cooling said at least one gelled microalgae and free of excess oil in the form of grains and/or said at least one of its gelled derivatives and free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or

equal to 4°C (*in particular from -20°C to 4°C*) and obtaining the aforementioned textured product as described above.

Interestingly, the invention also relates to a process for preparing a product according to the invention comprising at least the following steps:

- 5 a) removing excess oil present in at least one gelled microalgae in the form of grains and/or at least one of its gelled derivatives in the form of grains to obtain at least one gelled microalgae free of excess oil in the form of grains and/or at least one of its gelled derivatives and free of excess oil in the form of grains;
- 10 b) recovering at least one gelled microalgae and free of excess oil in the form of grains and/or at least one of its gelled derivatives and free of excess oil in the form of grains; and
- 15 c) cooling said at least one gelled microalgae and free of excess oil in the form of grains and/or said at least one of its gelled derivatives and free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or equal to 4°C (*in particular from -20°C to 4°C*) and obtaining the aforementioned textured product as described above.

Step iii) of removing excess oil may, interestingly, be carried out by means of a method:

- pressing; and/or
- draining; and/or
- 20 ▪ sponging; and/or
- centrifuging.

In particular, the pressing method is a moderate manual action to extract an additional fraction of oil from said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives, in the form of grains without denaturing the structure of the grains.

- 25 In particular, the draining method is a passive method allowing the majority of the excess oil to flow out by gravity. This is carried out using a metal mesh filter (smaller than the size of the grains of said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives, in the form of grains) for a period of approximately 2 minutes. For example, the mesh size of said filter is approximately 1 mm (ranging from 0.8 mm to 1.2 mm).

- 30 In particular, the sponging method is a manual action that absorbs the residual oil coating said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives, in the form of grains. This can be carried out with absorbent paper on which said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives, in the form of grains, is spread; said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains, being left in contact
- 35 with the absorbent paper for a period of approximately 5 minutes. Advantageously, the method of the invention involves removing excess oil by combining draining followed by sponging.

In particular, the centrifugation method is a process for separating oil by centrifugal force.

- 40 According to another embodiment, the invention therefore relates to the process as described above, wherein step iii) of removing excess oil is carried out by means of a draining method and/or a sponging method,

said draining method being carried out in particular by means of a wire mesh filter with a mesh size from 0.8 mm to 1.2 mm, wherein said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains, is (are) drained for a period from 1.5 minutes to 2.5 minutes,

5 and said sponging method being carried out in particular by means of absorbent paper on which said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives, in the form of grains, is/are spread and left for a period from 4.5 minutes to 5.5 minutes.

10 When the draining and sponging methods are combined, draining is advantageously carried out before sponging.

Furthermore, it should be noted that "excess oil" means oil that is not integrated/incorporated into the solid matrix of the grains of the product as described above. Advantageously, this step iii) is implemented since, by removing the excess oil, it makes it possible to obtain a product with a better nutritional profile.

15 In view of the above, it is also understood that, according to another embodiment, the subject matter of the invention relates to the process as described above, said process comprising at least one preliminary step of freezing and/or thawing at least one microalgae and/or at least one of its derivatives to obtain at least one frozen and/or thawed microalgae and/or at least one of its derivatives, frozen and/or thawed,

20 and at least the following steps:

- i) gelling at a temperature from 120°C to 160°C for a period from 5 minutes to 10 minutes of said at least one frozen and/or thawed microalgae and/or said at least one of its derivatives, frozen and/or thawed in an oil previously heated at a temperature from 120°C to 160°C, said gelation being carried out with stirring using non-cutting means, to obtain at least one frozen and/or thawed and gelled microalgae in the form of grains and/or at least one of its frozen and/or thawed and gelled derivatives in the form of grains;
- 25 ii) recovering said at least one frozen and/or thawed and gelled microalgae in the form of grains and/or said at least one of its frozen and/or thawed and gelled derivatives in the form of grains;
- 30 iii) removing excess oil present in said at least one frozen and/or thawed and gelled microalgae in the form of grains and/or said at least one of its frozen and/or thawed and gelled derivatives in the form of grains to obtain at least one frozen and/or thawed and gelled microalgae and free of excess oil in the form of grains and/or at least one of its frozen and/or thawed and gelled derivatives and free of excess oil in the form of grains; and
- 35 iv) cooling said at least one frozen and/or thawed and gelled microalgae and free of excess oil in the form of grains and/or said at least one of its frozen and/or thawed and gelled derivatives and free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or equal to 4°C (*in particular from -20°C to 4°C*) and obtain the aforementioned textured product as described above.
- 40

Step iv) of cooling is intended in particular to enable long-term storage of the product. This is particularly true when step iv) results in the freezing or deep-freezing of the product of the invention.

According to another embodiment, the subject matter of the invention relates to the process described above, wherein said at least one microalgae and/or said at least one of its derivatives is introduced into said oil in a mass ratio [*at least one microalgae and/or at least one of its derivatives: oil*] from [1:0.15] to [1:5]. This may therefore be [1:0.15], [1:0.30], [1:0.45], [1:0.60], [1:0.75], [1:0.90], [1:1], [1:1.05], [1:1.20], [1:1.35], [1:1.50], [1:1.65], [1:1.80], [1:1.95], [1:2], [1:2.10], [1:2.25], [1:2.40], [1:2.55], [1:2.70], [1:2.85], [1:3], [1:3.15], [1:3.30], [1:3.45], [1:3.60], [1:3.75], [1:3.90], [1:4], [1:4.05], [1:4.20], [1:4.35], [1:4.50], [1:4.65], [1:4.80], [1:4.95] or [1:5].

As mentioned above, the product of the invention is obtained from a raw material (at least microalgae and/or at least one of its derivatives) to which the process of the invention is applied. This raw material, like the product of the invention, has a texture that can be measured in a texture analysis using a texturometer. Also, according to another embodiment, the subject matter of the invention relates to the process as described above, wherein, in step i), said at least one microalgae and/or said at least one of its derivatives has a pH from 5.5 to 8.5 and a moisture content from 40% to 93%,

said at least one microalgae and/or said at least one of its derivatives having, in particular, the following properties:

- a hardness from 0.95 N to 1.052 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from -3.631 N.sec to -2.887 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 8.988 to 9.012 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.657 to 0.777 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 0.56 N to 0.738 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience of 0.008 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

said at least one microalgae and/or said at least one of its derivatives having optionally undergone, prior to step i), a freezing step followed, if desired, by a thawing step.

The expression "said at least one microalgae and/or said at least one of its derivatives has a pH from 5.5 to 8.5" means the possibility that the pH of the raw material is 5.5, 8.5 or a value from 5.5 to 8.5 (5.5; 5.6; 5.7; 5.8; 5.9; 6.0; 6.1; 6.2; 6.3; 6.4; 6.5; 6.6; 6.7; 6.8; 6.9; 7.0; 7.1; 7.2; 7.3; 7.4; 7.5; 7.6; 7.7; 7.8; 7.9; 8.0; 8.1; 8.2; 8.3; 8.4; 8.5). The pH can therefore also range from 5.5 to 8, from 5.5 to 7.5, from 5.5 to 7, from 5.5 to 6.5, from 5.5 to 6, from 6 to 8, from 6 to 7.5, from 6 to 7, from 6 to 6.5, from 6.5 to 8, from 6.5 to 7.5, from 6.5 to 7, from 7 to 8, or from 7 to 7.5.

The expression "said at least one microalgae and/or said at least one of its derivatives has [...] a moisture content from 40% to 93%" means the possibility that the moisture content of the raw material may be 40%, 93% or any value from 40% to 93%. Advantageously, the moisture content of the raw material is from 75% to 85%, from 75% to 80%, from 80% to 90%, or from 85% to 90%.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein, in step i), said at least one microalgae and/or said at least one of its derivatives has a pH from 5.5 to 8.5, a moisture content from 40% to 93% and the following properties:

- a hardness from 0.95 N to 1.052 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- optionally, an adhesiveness from -3.631 N.sec to -2.887 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.888 to 0.912 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.657 to 0.777 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 0.56 N to 0.738 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience of 0.008 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*).

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae and/or said at least one of its derivatives has (have) undergone, prior to step i), a freezing step (temperature below 0°C, in particular from -20°C to -4°C) followed optionally by a thawing step (temperature above 0°C, in particular from 4°C to 25°C). This preliminary step may correspond to the freezing and/or thawing step mentioned above. Advantageously, this is the case.

In particular, it should also be noted that the texture properties of the raw material described above are those of so-called fresh spirulina, which is ready for use. This may also be the case for other raw materials such as chlorella (green or white), klamath and/or the co-product resulting from the industrial processing of at least one microalgae (spirulina and/or chlorella and/or klamath). However, these sources (chlorella, klamath and co-product) may be more fluid or even completely liquid. A dehydration step should then be considered in order to obtain a moisture content from 40% to 93% (in particular from 75% to 80%) and the aforementioned texture properties.

According to another embodiment, the subject matter of the invention relates to the process as described above, wherein said at least one microalgae and/or said at least one of its derivatives undergoes a dehydration step to obtain at least one microalgae and/or said at least

one of its derivatives having a pH from 5.5 to 8.5, a moisture content from 40% to 93% and the following texture properties:

- 5 ▪ a hardness from 0.95 N to 1.052 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- optionally, an adhesiveness from -3.631 N.sec to -2.887 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- 10 ▪ an elasticity from 0.888 to 0.912 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.657 to 0.777 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- 15 ▪ a chewiness from 0.56 N to 0.738 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience of 0.008 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and
- 20 said at least one microalgae and/or said at least one of its derivatives having optionally undergone, prior to step i), a freezing step followed, optionally, by a thawing step.

According to another aspect of the invention, the subject matter of the invention relates to a textured product that can be obtained by the process described above.

25

According to another aspect of the invention, the subject matter of the invention relates to the use of the textured product as described above as a textured protein ingredient for the manufacture of a food product for human or animal consumption.

30 According to another aspect of the invention, the object is the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- a cooked dish, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,
- 35 said textured product having a moisture content from 30% to 71%.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- 40 ▪ a ready-made dish, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 30% to 71% and the following texture properties:

- a hardness from 6.09 N to 368.66 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.59 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 2.01 N to 10.12 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.13 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- a ready-made dish, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 30% to 40% (in particular from 35% to 37%) and the following texture properties:

- a hardness from 6.09 N to 368.66 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.05 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);

- a chewiness from 2.01 N to 9.19 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.14 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*),

in particular having an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- a ready-made dish, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 30% to 40% (in particular from 35% to 37%) and the following texture properties:

- a hardness from 6.09 N to 18.08 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.002 N.sec to 0.05 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.48 to 0.99 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.30 to 0.67 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 3.74 N to 15.56 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 2.01 N to 9.19 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.14 to 0.21 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- a ready meal, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 30% to 71% (in particular from 35% to 55%) and the following texture properties:

- a hardness of 38.844 ± 56.215 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness of 0.589 ± 1.71 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity of 0.549 ± 0.267 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion of 0.43 ± 0.127 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness of 10.121 ± 15.74 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience of 0.131 ± 0.047 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture:

- a meat substitute, such as minced beef, sausage, meatballs;
- a ready meal, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 40% to 45% (in particular 42%) and the following texture properties:

- a hardness of 13.112 ± 7.545 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness of -0.03 ± 0.027 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity of 0.612 ± 0.098 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion of 0.642 ± 0.04 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness of 5.085 ± 2.803 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and

- a resilience of 0.242 ± 0.049 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size of at least 5.5 mm, in particular from 7 mm to 8.5 mm.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture a *topping*, said textured product having a moisture content from 13% to 25%.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture a *topping*, said textured product having a moisture content from 13% to 25% (in particular from 13% to 14%) and the following texture properties:

- a hardness from 6.15 N to 16.46 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.01 N.sec to 4.77 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.49 to 0.98 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.10 to 0.55 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess value from 6.33 N to 9.76 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 3.79 N to 5.17 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.02 to 0.17 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size from 6 mm to 7 mm (in particular from 6.5 mm to 6.6 mm).

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture an animal feed, said textured product having a moisture content from 13% to 20%.

According to another aspect of the invention, the subject matter of the invention relates to the use as described above of the textured product as described above to manufacture an animal feed, said textured product having a moisture content from 13% to 20% (in particular from 13% to 14%) and the following texture properties:

- a hardness from 6.15 N to 16.46 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an adhesiveness from 0.01 N.sec to 4.77 N.sec in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- an elasticity from 0.49 to 0.98 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a cohesion from 0.10 to 0.55 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a gumminess from 6.33 N to 9.76 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*);
- a chewiness from 3.79 N to 5.17 N in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*); and
- a resilience from 0.02 to 0.17 in a texture analysis using a texturometer (*in particular with the same analysis parameters as for the product of the invention*), and

having, in particular, an average particle size from 6 mm to 7 mm (in particular from 6.5 mm to 6.6 mm).

In view of the foregoing, the subject matter of the invention also relates to the use as described above of the textured product as described above to manufacture a food product for human or animal consumption, in particular for manufacturing:

- a meat substitute, such as minced beef, sausage, meatballs;
- a ready-made dish, such as shepherd's pie, Bolognese sauce, chilli con carne and maki;
- a pastry, such as a chocolate cake,

said textured product having a moisture content from 30% to 71%;

or to manufacture a *topping*, said textured product having a moisture content from 13% to 25%;

or to manufacture an animal feed product, said textured product having a moisture content from 13% to 20%.

In all respects, it should be noted that the various aspects of the invention, as well as the various processes of implementation thereof, are interdependent. The latter may therefore be combined with each other to obtain advantageous aspects and/or processes of implementation of the invention not explicitly described. This also applies to all the definitions provided in this description, which apply to all aspects of the invention and its embodiments.

Furthermore, the present invention is illustrated, but not limited to, by the following Figures and Examples.

LIST OF FIGURES

Figure 1 shows a typical example of a graph obtained during the analysis of a texture profile.

Figure 2 is a photograph of the sample preparation step to remove excess oil before performing a texture analysis.

5 **Figure 3** is a photograph of the sample preparation stage in the vial where the texture analysis is performed. On the left is a photograph of the product correctly placed in the vial, while on the right is a photograph of a product that has been placed incorrectly.

10 **Figure 4** shows an optical microscopic observation of the product of the invention, where cell clusters and oil inclusions in the form of droplets are visible. (A) Observation of the textured product of Example 2 suspended in water at 200x magnification (1 cm = 100 μ m). (B) Observation of the textured product of Example 2 suspended in oil at 1,000x magnification (1 cm = 20 μ m).

15 **Figure 5** shows a confocal microscope observation of the product of the invention, where cell clusters and oil inclusions in the form of droplets are visible. (A) Observation of the textured product from Example 2 with a x630 oil immersion objective (green DNA staining (SYTO 9) + red lipid staining (bodipy); 1 cm = 20 μ m). (B) Observation of the textured product from Example 2 with a 630x water immersion objective (green protein staining (fastgreen) + red lipid staining (bodipy); 1 cm = 20 μ m).

Figure 6 is a photograph of the textured product obtained in Example No. 3.

20 **Figure 7** shows photographs of the textured products obtained in Example No. 5. Left: 5% fibre; right: 20% fibre.

Figure 8 is a photograph of the chilli obtained in Example No. 6.

Figure 9 shows photographs of the chilli maki rolls obtained in Example No. 7. On the left, they are being prepared, and on the right, they are assembled.

25 **Figure 10** is a photograph of a patty obtained in Example No. 8.

Figure 11 is a photograph of a chocolate cake obtained in Example No. 9.

Figure 12 is a photograph of a vegetable mince obtained in Example No. 10.

Figure 13 is a photograph of a vegetable shepherd's pie obtained in Example No. 11.

30 **Figure 14** shows photographs of the textured products obtained in Example No. 12. On the left is sunflower oil; in the centre is deodorised sunflower oil; on the right is frying sunflower oil.

Figure 15 shows photographs of the textured products obtained in Example No. 13.

Figure 16 shows photographs of the textured products obtained in Example No. 14. On the left, 7% starch; on the right, 12% starch.

35 **Figure 17** shows photographs of the textured products obtained in Example No. 15. On the left, 5% co-product; on the right, 30% co-product.

EXAMPLES

- EXAMPLE No. 1 - Manufacture of various textured products according to the invention

Materials & Methods

Ingredients

- 500 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 100 g fresh spirulina. This was stored frozen or deep-frozen. Although it can be used after thawing or in frozen form, it was decided to process it in frozen form, diced. This raw material has a pH from 5.5 to 6.5, a moisture content from 40% to 93% and the following texture properties:
 - a hardness of 1.001 ± 0.051 N in a texture analysis using a texturometer;
 - optionally, an adhesiveness of -3.259 ± 0.372 N.sec in a texture analysis using a texturometer;
 - an elasticity of 0.888 ± 0.012 in a texture analysis using a texturometer;
 - a cohesion of 0.717 ± 0.06 in a texture analysis using a texturometer;
 - a chewiness of 0.649 ± 0.0089 N in a texture analysis using a texturometer; and
 - a resilience of 0.008 in a texture analysis using a texturometer.

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R) in excess oil (500 g of oil per 100 g of spirulina). The contents of the tank were stirred by a double blade placed in counter-rotation (anti-clockwise) and the following configurations were used:

Configuration	Initial temperature (°C)	Duration (min)	Stirring speed (rpm, counter-clockwise)	Moisture content of raw material (%)
--+	125	8	-250	57.5
-	125	6	-150	72.5
++	135	6	-250	57.5
++-	135	6	-150	57.5
0000	130	7	-200	65
+++-	135	8	-250	72.5
----	125	6	-250	57.5
00A0	130	7	-100	65
++	135	6	-150	72.5
+++	135	8	-150	57.5
----+	125	6	-250	72.5
A000	140	7	-200	65
000a	130	7	-200	50
a000	120	7	-200	65
---+	125	6	-150	57.5
---+	125	8	-150	57.5
0A00	130	9	-200	65
++	135	6	-250	72.5
0000	130	7	-200	65
000A	130	7	-200	80
0a00	130	5	-200	65
++	125	8	-250	72.5

++--	135	8	-250	57.5
--++	125	8	-150	72.5
00a0	130	7	-300	65
++++	135	8	-150	72.5

Table 1. Parameters for implementing the invention process

The gelled spirulina was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Measurement of particle size

Equipment

- White A4 sheet
- ImageJ software

Method

Place the camera on a tripod.

Place 10 g of the product on a white sheet of paper.

Photograph the sheet.

Using ImageJ software, process the photograph to measure all the grains by applying the following macro:

```
run("Set Scale...", "distance=2128.0601 known=210 unit=mm");
```

```
//setTool("rectangle");
```

```
makeRectangle(24, 168, 2160, 2968);
```

```
run("Crop");
```

```
run("8-bit");
```

```
//run("Threshold...");
```

```
//setThreshold(0, 59);
```

```
run("Convert to Mask");
```

```
run("Analyze Particles...", "size=0.2-Infinity show=[Overlay Masks] display  
exclude include  
overlay composite");
```

Moisture content measurement

Equipment

- Precision balance
- oven
- cups

Method

For each sample, weigh approximately 1 g exactly into a crucible.

Prepare three crucibles per sample (triplicates).

Place the crucibles at 100°C for 6 hours.

Weigh again accurately.

The difference in mass corresponds to the water that has evaporated.

Texture measurement

Sample preparation

1. Place the sample on a paper towel without pressing down on it. Leave the sample for 5 minutes to remove excess oil (Figure 2).
2. Weigh 5 grams of the sample into a 40 mL vial. Use a spoon with a smaller diameter than the bottle and place the sample as evenly as possible inside (Figure 3). The sample must be handled gently so as not to deform it.
3. Tap the bottle against the work surface five times with a light, quick movement. It is important for the measurement that the surface is as flat as possible.

Software preparation

The methodology selected to evaluate the texture of the sample was texture profile analysis (TPA), which consists of two consecutive compressions over a specific period. The Exponent software provides a Project macro to run the TPA and requires five files to function correctly. These files are:

- TPA.P.R.J.
- TPA32.MAC
- TPA.SET
- TPA.PRF
- TPA.RPT

A 20 mm probe was attached to the Stable Micro Systems texturometer - model TA-HD plus, which was equipped with a 5 kg load cell.

1. Set the height limit by placing the probe at the base of the equipment and inserting the safety pin located on the right side of the texturometer.
2. Press the T.A./T.A. Settings tab and adjust the following test conditions:
 - Pre-test speed: 1 mm/s
 - Test speed: 2 mm/s
 - Post-test speed: 1 mm/s
 - Target mode: Distance
 - Distance: 10 mm
 - Time: 2 seconds
3. Position the sample under the probe and place the probe approximately 1 cm before it touches the sample.
4. Select from the "T.A./Run a test..." tab.
5. Hold the dish gently during the test to avoid movements that could affect the measurements.
6. Once the test is complete, select the Process Data/Macro/Run tab to calculate the TPA parameters. A pop-up box will appear to confirm the selection of peaks. The data is saved in a file called TPA.rsl, which must be exported to Excel to download the information.
7. Perform at least 3 repetitions for each sample.

Results

Implementation of the process according to the invention enabled the manufacture of 26 textured products according to the invention. Texture analysis, moisture content and particle size measurements were performed and the data obtained are summarised in the tables below.

Configuration	Moisture content (%)	Hardness (N)	Adhesiveness (N.sec)	Elasticity	Cohesion
000A	39.41%	20.2422		0.4146	0.4734

000A	40.59%	12.1376	0.0124	0.4476	0.4659
000A	39.79%	23.7721	0.0338	0.5644	0.4918
000A	39.93%	17.7015		0.4156	0.4644
000A		19.6180		0.9890	0.4765
+-+-	42.34%	42.0554	0.1593	0.3247	0.4510
+-+-	42.90%	46.7030	0.1353	0.3247	0.4638
+-+-	43.18%	16.4857	0.0689	0.2747	0.3698
+-+-		87.5050	1.7294	0.9980	0.4304
----	43.57%	7.2670	0.0268	0.3397	0.3494
----	44.69%	19.7925	0.1071	0.3277	0.3695
----		12.8803	0.0850	0.3277	0.3943
----		17.3497	0.0803	0.3017	0.3959
--+-	42.25%	19.4567	0.0868	0.4076	0.4129
--+-	42.27%	15.3868	0.0509	0.3516	0.4047
--+-	41.97%	36.2469	0.1267	0.4456	0.4690
--+-		33.4800	0.0704	0.2987	0.4318
--+-		9.9741	0.1590	0.2438	0.3816
+-	33.82%	50.9060	0.0794	0.4296	0.4658
+-	34.16%	17.3376	0.0307	0.3506	0.4322
+-	34.78%	54.3365	0.0512	0.3836	0.4605
+-		25.0340	0.1203	0.6683	0.4688
-++-	42.76%	58.7441	0.3018	0.3696	0.5056
-++-	43.62%	12.1404	0.0948	0.3187	0.3753
-++-	44.28%	10.8629	0.0868	0.2228	0.3562
-++-		28.9028	0.0311	0.6024	0.4146
-++-		71.1982	0.0354	0.3746	0.4435
++--	27.09%	60.3110	0.0172	0.3387	0.4355
++--	28.00%	93.7499		0.8821	0.4505
++--	27.70%	177.8526	0.1329	0.9890	0.4831
++--		105.0160	0.0630	0.4785	0.4611
-+--	27.71%	97.9965	0.0494	0.3646	0.4573
-+--	27.07%	122.4444	0.1057	0.9860	0.4661
-+--	27.26%	102.0469		0.5704	0.4592
-+--		44.5428	0.0677	0.3796	0.4704
+++-	36.03%%	33.2790	0.0275	0.3027	0.4428
+++-	34.96%	24.3075	0.0463	0.3606	0.4196
+++-	35.55%	15.4159	0.0259	0.3417	0.3948
+++-		18.1412		0.3467	0.3960
+++-		59.5874	0.2722	0.4186	0.4711
0A00	40.58%	9.2529	0.0311	0.2378	0.3567
0A00	40.95%	31.5767	0.0635	0.3826	0.4434
0A00	38.41%	14.2954	0.0247	0.3616	0.3816
0A00		4.6113	0.0518	0.3347	0.3456
0A00		33.5765	0.0559	0.2138	0.4311

0A00		13.4536	0.0301	0.2218	0.3635
00A0	40.03%	109.0848	3.2106	0.9980	0.2960
00A0	39.66%	19.9630	0.0632	0.3257	0.3829
00A0	39.97%	10.3733	0.0246	0.2088	0.3428
00A0		26.5232	0.0656	0.3956	0.4323
0	33.93%	74.3697	0.4656	0.9890	0.4928
0	34.54%	87.3994	0.2379	0.3856	0.5665
0	35.14%	31.3356	0.0875	0.4655	0.4531
0		18.4961	0.0985	0.4605	0.4552
0		16.9627	0.0184	0.2547	0.3923
A000	37.37%	19.1115	0.0277	0.3387	0.3781
A000	36.32%	14.6310	0.0152	0.3217	0.3875
A000	36.55%	22.3771	0.0580	0.4795	0.4531
A000		23.5908	0.0045	0.4905	0.4432
A000		29.0451	0.0829	0.4615	0.4099
0	31.26%	51.1303	0.1033	0.9880	0.5288
0	33.14%	18.8086	0.0138	0.3976	0.4303
0	32.85%	16.7822	0.0111	0.3077	0.4067
0		65.4463	0.0384	0.4935	0.4661
0		31.4834	0.0047	0.3686	0.4089
A000	27.75%	76.0994		0.9880	0.4820
A000	27.81%	72.9501		0.5564	0.4415
A000	28.35%	52.0036	0.0039	0.3856	0.4450
A000		21.3632	0.0094	0.3806	0.4506
00A0	31.04%	14.6564	0.0069	0.2228	0.3753
00A0	29.80%	10.9487	0.0074	0.2258	0.3740
00A0	29.25%	13.2562	0.0128	0.2947	0.3877
00A0		9.3292	0.0146	0.2338	0.3506
00A0		80.2493		0.5385	0.4696
00A0		47.0592	0.0192	0.3237	0.4495
0A00	25.37%	19.0037	0.0092	0.4096	0.4032
0A00	26.53%	68.6489		0.3706	0.4508
0A00	28.91%	35.0676	0.6195	0.9980	0.4643
0A00		36.7868	0.4566	0.9980	0.4599
---+	52.15%	10.0404	0.0512	0.4406	0.5261
---+	52.33%	23.2034	0.0498	0.3786	0.5131
---+	55.43%	14.6910	0.0336	0.4136	0.5277
---+		4.2786	0.0199	0.9900	0.5726
---+		6.6294	0.0652	0.4186	0.5435
---+		4.4107	0.0170	0.4895	0.5780
---+		2.8027	0.0467	0.6174	0.6332
----+	49.05%	40.2681	1.5510	0.9970	0.3787
----+	49.29%	14.2099		0.5035	0.6103
----+	49.28%	29.8121	0.4228	0.9980	0.4779

----+		9.0310	0.2890	0.9890	0.5482
----+		21.4791	0.0133	0.5994	0.6024
+---+	34.60%	13.7725	0.0260	0.5305	0.5802
+---+	33.48%	25.9358	0.0246	0.5904	0.5998
+---+	33.82%	17.2659	0.0020	0.5465	0.5827
+---+		7.5248		0.5065	0.5543
+---+		9.9471	0.0369	0.9570	0.5554
+---+	38.00%	6.7299		0.5375	0.5554
+---+	37.37%	13.6646		0.5435	0.5725
+---+	39.30%	17.1229	0.0010	0.5305	0.5697
+---+		17.3483	0.0025	0.7303	0.6546
+---+		12.0761		0.7083	0.6560
++++	35.48%	11.9076		0.5814	0.6556
++++	36.57%	10.5772	0.0450	0.5994	0.6375
++++	36.03%	18.0826	0.0049	0.6633	0.6659
++++		335.9684			
++++		368.6559		0.9900	0.3007
-+++	36.77%	137.9140		0.7343	0.4005
-+++	35.03%	305.6619		0.6344	0.4253
-+++	35.01%	7.5030		0.4925	0.5603
-+++		6.0853	0.0017	0.4825	0.5372
++-+	13.73%	6.1519	0.0112	0.5205	0.5278
++-+	13.29%	7.5660	0.0092	0.4905	0.5468
++-+	13.99%	16.4565	4.1553	0.9800	0.0964
++-+		15.7246	4.7690	0.9800	0.1244
-+++	46.89%	15.6180	10.2105	0.9780	0.1554
-+++	47.76%	15.8445	5.4003	0.9850	0.1386
-+++	46.56%	13.9712	1.7595	0.9850	0.2226
-+++		15.8445	5.4003	0.9850	0.1386
-+++		13.9712	1.7595	0.9850	0.2226
000A	68.61%	16.4565	4.1553	0.9800	0.0964
000A	69.89%	15.7246	4.7690	0.9800	0.1244
000A	70.51%	15.6180	10.2105	0.9780	0.1554
000A		15.8445	5.4003	0.9850	0.1386
000A		13.9712	1.7595	0.9850	0.2226

Table 2. Texture and moisture content of textured products obtained

Configuration	Gumminess (N)	A chewiness (N)	A resilience	Particle size (Average diameter; mm)
000A	9.5827	3.9729	0.1396	7.2091
000A	5.6545	2.5307	0.1366	
000A	11.6905	6.5985	0.1444	

000A	8.2212	3.4166	0.1327	
000A	9.3478	9.2451	0.1357	
+--+	6.5373	1.5282	0.1292	6.2169
+--+	28.7651	13.0176	0.1452	
+--+	18.9661	6.1578	0.1024	
+--+	21.6594	7.0323	0.1940	
----	6.0968	1.6749	0.0896	6.3843
----	37.6623	37.5871	0.0952	
----	36.1994	36.0548	0.1070	
----	2.5393	0.8625	0.1092	
+-	34.3686	34.2312	0.1105	6.1324
--+-	7.3138	2.3965	0.1073	
--+-	5.0789	1.6642	0.1234	
--+-	6.8685	2.0722	0.1334	
--+-	8.0344	3.2748	0.1181	
----	6.2269	2.1897	0.1405	4.7599
----	16.9982	7.5736	0.1252	
----	14.4560	4.3180	0.1422	
----	3.8058	0.9277	0.0986	
-++-	23.7130	10.1864	0.1871	5.9585
-++-	7.4936	2.6276	0.0905	
-++-	25.0202	9.5982	0.0947	
-++-	11.7360	7.8436	0.1273	
-++-	3.4621	0.7920	0.1389	
++--	3.3078	0.6444	0.1382	4.5770
++--	29.7039	10.9795	0.1459	
++--	4.5563	1.4520	0.1601	
++--	3.8695	0.8620	0.1463	
-+--	11.9829	7.2185	0.1472	5.0888
-+--	31.5742	11.8285	0.1538	
-+--	26.2679	8.8959	0.1457	
-+--	42.2362	37.2573	0.1419	
+++-	85.9183	84.9742	0.1341	4.7279
+++-	48.4180	23.1690	0.1220	
+++-	44.8105	16.3395	0.1182	
+++-	57.0662	56.2680	0.1027	
+++-	46.8614	26.7311	0.1731	
0A00	20.9533	7.9543	0.0997	5.0693
0A00	8.1002	2.1039	0.1163	
0A00	14.7352	4.4603	0.0978	
0A00	10.2006	3.6787	0.0879	
0A00	6.0864	2.0795	0.1261	
0A00	7.1833	2.4901	0.0950	
00A0	28.0744	11.7514	0.1560	4.1891

00A0	3.3008	0.7848	0.0970	
00A0	14.0012	5.3571	0.0942	
00A0	5.4550	1.9727	0.1096	
0	1.5938	0.5334	0.1906	5.5036
0	24.2718	17.0703	0.2269	
0	14.4746	3.0945	0.1263	
0	4.8899	1.0845	0.1067	
0	32.2916	32.2271	0.1146	
A000	7.6429	2.4891	0.1051	4.7787
A000	3.5564	0.7425	0.1079	
A000	11.4658	4.5359	0.1125	
A000	52.0129	51.4933	0.1286	
A000	36.6476	36.2449	0.1243	
0	49.5150	19.0937	0.1431	5.2061
0	14.1997	6.6105	0.1294	
0	8.4194	3.8775	0.1256	
0	6.6541	1.6951	0.1391	
0	7.2261	2.4472	0.1257	
A000	5.6700	1.8239	0.1463	5.4554
A000	10.1395	4.8621	0.1341	
A000	10.4544	5.1280	0.1339	
A000	11.9060	5.4951	0.1295	
00A0	27.0396	26.7154	0.1213	5.4702
00A0	8.0943	3.2183	0.1237	
00A0	6.8245	2.0999	0.1255	
00A0	30.5015	15.0527	0.1144	
00A0	12.8736	4.7456	0.1529	
00A0	36.6797	36.2400	0.1437	
0A00	32.2043	17.9199	0.1247	5.7685
0A00	23.1400	8.9231	0.1434	
0A00	9.6259	3.6638	0.1366	
0A00	2.0560	1.1872	0.1656	
---+	5.5004	1.2254	0.1474	8.8505
---+	4.0953	0.9246	0.1625	
---+	1.0736	0.2327	0.1511	
---+	5.1391	1.5145	0.1591	
---+	3.2709	0.7646	0.1605	
---+	37.6886	20.2938	0.1828	
---+	21.1516	6.8463	0.1946	
----+	7.6615	3.1381	0.1102	7.6060
----+	30.9491	11.4706	0.1920	
----+	16.2819	16.2494	0.1425	
----+	16.9194	16.8856	0.1585	
----+	1.8537	0.8000	0.1827	

++--	5.2819	2.3270	0.1790	5.6850
++--	11.9048	4.5074	0.1871	
++--	7.7528	3.2064	0.1772	
++--	2.4498	2.4253	0.1771	
++--	3.6029	1.5081	0.1744	
++--	2.5495	1.2480	0.1789	6.9752
++--	1.7747	1.0957	0.1878	
++--	15.2485	15.2028	0.1840	
++--	8.6727	4.3667	0.2147	
++--	14.2469	14.2184	0.2057	
++++	4.9511	4.8967	0.2128	8.2493
++++	12.9399	7.7562	0.2143	
++++	7.9903	4.2386	0.2135	
++++	15.5575	9.1853	0.1602	
++++	10.0610	5.4979	0.1425	
--++	4.1709	2.1125	0.1642	7.0094
--++	5.5246	5.2873	0.1601	
--++	3.7380	2.0091	0.1799	
--++	7.8228	4.2513	0.1673	
++--	9.7551	5.1748	0.1629	6.5596
++--	6.3342	4.1258	0.1731	
++--	8.2421	4.5451	0.0187	
++--	6.5540	3.7910	0.0195	
--++	9.3043	5.5305	0.0163	8.9114
--++	10.8187	6.3767	0.0200	
--++	11.3565	8.2933	0.0358	
--++	7.9220	5.6111	0.0200	
--++	7.8067	4.5390	0.0358	
000A	6.7430	4.0418	0.0187	10.2482
000A	12.0417	7.9877	0.0195	
000A			0.0163	
000A	110.8487	109.7413	0.0200	
000A	55.2395	40.5605	0.0358	

Table 3. Texture and particle size of the textured products obtained

All the products obtained are textured. Interestingly, among them, the products with the '++++' and '-+--' configurations showed particularly interesting properties for use in the manufacture of more complex food products such as meat substitutes or protein ingredients. The product of the '+--+' configuration also showed particularly interesting properties, but this time for use in the manufacture of *topping-type* food products or products intended for animal feed.

- EXAMPLE No. 2 - Manufacture of a textured product according to the invention for use as a meat substitute

Materials & Methods

Ingredients

- 500 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 5 ▪ 100 g fresh spirulina with a moisture content of 73% (see Example No. 1).

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R).

Process

- 10 The oil was preheated at 136°C. The fresh spirulina, frozen and diced, was placed in the Robot Cook® (sold by Robot coupe®, reference RR43000R) and the contents of the bowl were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for 6 minutes 20 seconds. The gelled spirulina was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and
- 15 then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Confocal microscopy

EQUIPMENT:

- 20 – confocal microscope (ZEISS® LSM 900)
- SYTO 9 DNA marker (excitation: $\lambda_{\text{ex}} = 488 \text{ nm}$; emission: $498 \text{ nm} < \lambda_{\text{em}} < 571 \text{ nm}$)
- Bodipy lipid marker (excitation: $\lambda_{\text{ex}} = 638 \text{ nm}$; emission: $648 \text{ nm} < \lambda_{\text{em}} < 734 \text{ nm}$)
- fastgreen protein marker (excitation: $\lambda_{\text{ex}} = 488 \text{ nm}$; emission: $499 \text{ nm} < \lambda_{\text{em}} < 620 \text{ nm}$)
- slide
- 25 – cover slip

METHOD:

- 1 - Perform SYTO 9 and Bodipy staining by suspending the product obtained in the dye. Shake and then rinse with distilled water. Place the product obtained from the slide and cover slip, then observe at 630x magnification with an oil immersion objective.
- 30 2 - Perform fastgreen and Bodipy staining by suspending the product obtained in the dye. Shake and then rinse with distilled water. Place the product obtained from the slide and cover slip, then observe at 630x magnification with a water immersion objective.

Optical microscopy

EQUIPMENT:

- 35 – optical microscope (Zeiss®, AxioLab A1 model)
- slide
- cover slip

METHOD:

- Place a fragment of grain from the product obtained on a slide with a drop of water. Place a
- 40 cover slip and observe at different magnifications.

Moisture content measurement

See Example No. 1

Texture measurement

See Example No. 1

Results

The texture analysis performed on this textured product, which has a moisture content of around 42%, and on minced beef (control) yielded the following comparative data:

	Minced beef	Textured product
Hardness (N)	13.556 ± 6.117	13.112 ± 7.545
Adhesiveness (N.sec)	-0.019 ± 0.036	-0.03 ± 0.027
Elasticity	0.775 ± 0.124	0.612 ± 0.098
Cohesion	0.657 ± 0.018	0.642 ± 0.04
Chewiness (N)	6.827 ± 3.165	5.085 ± 2.803
Resilience	0.243 ± 0.016	0.242 ± 0.049

Table 4. Texture comparison

Microscopic observation of this product revealed the existence of cell clusters with oil inclusions in the form of droplets (Figures 4 and 5). In addition, the process described above provided optimal conditions for the product of the invention to be comparable to a meat substitute in terms of texture and be used as such.

- EXAMPLE No. 3 - Manufacture of a textured product according to the invention

Materials & Methods*Ingredients*

- 800 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 250 g fresh spirulina (see Example No. 1).

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R).

Process

The oil was preheated at 136°C. The fresh spirulina, frozen and diced, was placed in the Robot Cook® (sold by Robot coupe®, reference RR43000R) and the contents of the bowl were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -160 rpm for 10 minutes. The gelled spirulina was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Moisture content measurement

See Example No. 1

Measurement of particle size

See Example No. 1

Results

The textured product obtained has a similar appearance to the other textured products above (Figure 6). Furthermore, analyses have shown that it has a moisture content of around 52.13% and an average particle size of 5.48 mm.

- EXAMPLE No. 4 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients

- 10 ▪ 500 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 50 g fresh spirulina (see Example No. 1)
- 50 g co-product from phycocyanin extraction from spirulina

Food processor

- 15 The raw material was gelled using a Robot Cook® (sold by Robot Coupe®, reference RR43000R).

Process

- 20 The oil was preheated at 136°C. The frozen, diced spirulina/co-product mixture was placed in the Robot Cook® (sold by Robot coupe®, reference RR43000R) and the contents of the bowl were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for 6 minutes and 20 seconds. The gelled spirulina/co-product mixture was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina/co-product mixture
- 25 was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Results

The textured product obtained has an appearance and texture similar to the other textured products above.

- EXAMPLE No. 5 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients - 5% fibre

- 35 ▪ 250 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 114 g fresh spirulina (see Example No. 1)
- 6 g oat bran fibre

Ingredients - 20% fibre

- 40 ▪ 250 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)

- 96 g fresh spirulina (see Example No. 1)
- 24 g oat bran fibre

Food processor

5 The mixture of thawed microalgae and fibre was prepared using a KitchenAid® food processor (model artisan reference 5KSM125EER) sold by KitchenAid®.

Method

10 The oil was preheated at 150°C in a container placed on a hotplate. The spirulina/fibre mixture was added to the oil and stirred using non-sharp utensils for 3.45 minutes. The gelled spirulina/fibre mixture was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina/fibre mixture was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Results

15 The textured products obtained have an appearance and texture similar to the other textured products above (Figure 7, left 5% fibre; right 20% fibre).

- EXAMPLE No. 6 - Manufacture of chilli sauce

Materials & Methods

20 *Ingredients*

<i>Vegetable base</i>		
23	mL	Olive oil
100	g	Finely chopped yellow onion
12	g	Very finely chopped garlic
70	g	Diced carrot
10	g	Red pepper, sliced
3.5	g	Salt
12	g	Double concentrated tomato paste
1000	g	Tomato pulp
280	g	Red beans
120	g	Corn
2	g	Cumin
2	leaf	Bay leaf
1.8	g	Thyme leaves

Table 5. Plant-based ingredients

<i>Microalgae textured like minced beef</i>		
450	g	Frozen textured microalgae (Example No. 2)
20	g	Chopped garlic
30	mL	Olive oil

10	g	Cornflour
5	g	Salt
100	g	Double concentrated tomato paste
0.4	L	Water
75	g	Cornflour

Table 6. Ingredients of the meat substitute base

Method

- 5 Mix the frozen textured microalgae with salt and finely chopped garlic for 30 seconds. Add the cornflour and mix for 30 seconds to coat the product thoroughly. Pour the oil into a frying pan and fry the textured microalgae over a high heat for 2 minutes. Mix the tomato paste with the water. Pour the tomato mixture into the frying pan. Leave to thicken for 3 minutes or until the liquid has evaporated. Transfer to a flat container and place the mixture in a cooling chamber at 3°C for 20 minutes.
- 10 Pour the oil into a hot frying pan, then add the onion, garlic, carrots and salt. Brown for 5 minutes over high heat. Add the remaining ingredients, then simmer over low heat, covered, for 15 minutes. Place the mixture in a cooling chamber at 3°C for 20 minutes.
- 15 Coarsely break up the textured microalgae mixture with a fork for 30 seconds. Gently mix the two cold mixtures together for 1 minute.

Results

See Figure 8.

- EXAMPLE No. 7 - Making maki

20 Materials & Methods

Ingredients

<i>Vinegared rice</i>		7 rolls = 42 maki rolls
450	g	sushi rice
63	mL	water
75	mL	rice vinegar
45	g	sugar
10	g	salt

Table 7. Ingredients for vinegared rice

<i>Garnish</i>			
7		nori seaweed sheets	
84	g	carrots	(4 sticks/roll)
105	g	cucumber	(4 sticks/roll)
112	g	Frozen textured microalgae (Example No. 2)	

910	g	vinegared rice	
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Table 8. Ingredients for the filling*Method***- Vinegared rice -**

- 5 Wash the rice until the water runs clear. Drain the rice in a colander. Pour the water and rice into a saucepan with a lid. Bring to the boil, cook over medium heat for 2 minutes, then over low heat for 10 minutes. Cover and let stand for 10 minutes. Mix the rice vinegar, salt and sugar until dissolved. Put the rice in a bowl and add the vinegar mixture. Fluff the rice until it reaches room temperature.

- Making the maki -

- 10 Spread 130 g of rice over $\frac{3}{4}$ of the nori seaweed sheet (using wet fingers). Place 12 g of carrot and 15 g of cucumber at the end of the rice (4 sticks of each). Place 16 g of textured microalgae protein along the vegetables. Roll the maki to the end of the rice using the mat. Moisten the remaining nori seaweed and finish rolling the maki. Cut the roll into pieces of about 3 cm, by placing the vegetables at the top and the textured protein at the bottom.

15 Results

See Figure 9.

- EXAMPLE No. 8 - Making a patty**Materials & Methods****20 Ingredients**

green lentils	160 g
breadcrumbs	50 g
onion	100 g
garlic	7 g
egg	55 g
salt	1.5 g
Frozen textured microalgae (Example No. 2)	100 g
total	473.5 g

Table 9. Ingredients for the patty*Method*

- 25 Drain the cooked lentils and rinse them under running water. Wash and finely chop the onion. Mix all the ingredients together by hand in a salad bowl, except for the textured microalgae. Place half of the mixture in the food processor and blend for 1 minute until smooth. Mix for 2 minutes with the other half and gently fold in the textured microalgae. Form patties about 2 cm thick. Heat the olive oil in a frying pan and brown the patties on both sides, 3 minutes per side.

Results

See Figure 10.

- EXAMPLE No. 9 - Making a chocolate cake

Materials & Methods

5 *Ingredients*

Baking chocolate	200 g
Butter	60 g
flour	50 g
sugar	100 g
eggs	165 g
Frozen textured microalgae (Example No. 2)	180 g
total	755 g

Table 10. Ingredients for chocolate cake

Method

Preheat your oven to 180°C (thermostat 6). In a saucepan, melt the chocolate and butter cut into pieces over a very low heat until the mixture is completely melted. In a mixing bowl, add the sugar, eggs and flour. Mix for 2 minutes. Add the chocolate/butter mixture. Mix for 1 minute. Gently fold in the textured microalgae. Mix gently for 30 seconds. Pour the cake batter into a square cake tin (25 x 25 x 5 cm). Bake for 20 minutes.

Results

See Figure 11.

15

- EXAMPLE No. 10 - Making a vegetable mince

Materials & Methods

Ingredients

- Infused garlic oil -

20 30 mL rapeseed oil
 15 g fresh garlic

- Textured microalgae protein -

25 50 g frozen textured microalgae protein (Example No. 2)
 0.5 g paprika powder
 0.15 g salt
 8 g tomato paste
 5 g cornflour

30 - Tomato coating -

 10 g double tomato paste
 0.5 g salt
 0.2 g ground paprika

25 mL water
2 g cornflour

Method

- Infused garlic oil -

- 5 In a blender, combine the rapeseed oil and fresh garlic. Blend until smooth. Pass the mixture through a sieve to collect the infused garlic oil.

- Textured microalgae protein -

- 10 In a bowl, mix the paprika powder, salt and tomato paste for 30 seconds. Add the frozen textured microalgae protein and mix gently for 30 seconds to coat it well. In another bowl, pour in the cornflour. Add the textured microalgae protein and mix for 30 seconds to coat it well with cornflour. Pour 5 ml of infused garlic oil into a frying pan. Heat the oil over medium heat until it reaches the point where it begins to sizzle slightly. Add the textured microalgae protein to the pan. Continue cooking over medium heat, stirring very little and very gently for 2 minutes. The
15 cornflour should no longer be visible and the textured microalgae protein should be very lightly browned. Then set the textured microalgae protein aside in a cooling cell for 15 minutes at 3°C.

- Tomato coating -

- 20 In a bowl, mix the double tomato paste with the salt, ground paprika, cornflour and water for 30 seconds. Pour this mixture into a frying pan. Bring to the boil over medium heat for 1 to 2 minutes, stirring constantly to prevent the mixture from sticking. Once the mixture has thickened, remove from the heat and gently add the textured microalgae protein. Spread the mixture evenly in the pan, making sure to create a thin layer. Reheat over low heat for 2
25 minutes, stirring gently and carefully to avoid damaging the structure of the textured microalgae protein. The goal is to allow the liquid to be partially absorbed. Set the mixture aside in a cooling cell.

- Finishing and tasting -

- 30 Once cooled, remove the textured microalgae protein. To enjoy, reheat in the microwave for 1 minute or incorporate into the preparation of your choice.

Results

See Figure 12.

35 - **EXAMPLE No. 11 - Making a vegetable shepherd's pie**

Materials & Methods

Ingredients

- Textured microalgae protein -

- 40 42 g frozen textured microalgae protein (Example No. 2)
10 g finely chopped onion
3 g finely chopped garlic
10 g tomato paste
4 g olive oil
3.5 g cornflour

1.5 g Kub Or® (sold by Maggi®, Nestlé®)
 0.1 g ground grey pepper
 0.3 g salt
 50 mL water

5

- Mashed potatoes -

25 g Mousline® mashed potato flakes (sold by Maggi®, Nestlé®)
 80 mL milk
 70 mL water

10

0.5 g salt

- Assembly -

10 g grated Emmental cheese

Method

15 - Textured microalgae protein -

In a frying pan, sauté the onions and garlic in olive oil over medium heat for 3 minutes. In a bowl, mix the cornflour, salt, pepper, tomato paste, crumbled Kub Or® (sold by Maggi®, Nestlé®) and water. Pour this mixture over the sautéed onions and bring to the boil. Reduce the sauce for 1 to 2 minutes over high heat until it reaches a thick, paste-like consistency.

20 Remove from the heat, add the frozen textured microalgae protein and mix gently.

- Mousline® purée (sold by Maggi®, Nestlé®) -

In a saucepan, bring the milk and water to the boil. Add the Mousline® mashed potato flakes (sold by Maggi®, Nestlé®) and salt. Whisk well and simmer for a few minutes until the mashed potato thickens. Remove from the heat.

25

- Assembling the dish -

Spread the textured microalgae protein mixture over the bottom of an ovenproof dish. Add the mashed potato on top, covering the textured microalgae protein base. Sprinkle with grated cheese to cover the mashed potato.

30

- Baking -

Preheat your oven at 180°C on the grill and fan setting. Bake for 20 minutes until the cheese is golden brown and the mixture is piping hot. Cool using a cooling cell.

35

- Serving -

To serve, reheat in the microwave for 2 minutes or in the oven at 160°C for 10 minutes.

Results

See Figure 13.

40

- EXAMPLE No. 12 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients

- 500 g vegetable oil

- 100 g fresh spirulina (see Example No. 1)

The vegetable oils tested were sunflower oil, deodorised sunflower oil and frying sunflower oil.

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R).

Process

The oil was preheated at 136°C. The frozen, diced spirulina/co-product mixture was placed in the Robot Cook® (sold by Robot coupe®, reference RR43000R) and the contents of the tank were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -200 rpm for 6 minutes. The gelled spirulina was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Results

The textured products obtained have an appearance, taste and texture similar to the textured product of Example No. 2 (Figure 14, left: sunflower oil; centre: deodorised sunflower oil; right: frying sunflower oil).

- EXAMPLE No. 13 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients

- 250 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 120 g of a mixture of fresh spirulina (see Example No. 1) and flour

Food processor

The mixture of thawed microalgae and flour was prepared using a KitchenAid® food processor (model artisan reference 5KSM125EER) sold by KitchenAid®.

Method

The oil was preheated at 150°C or 160°C in a container placed on a hotplate. The spirulina/flour mixture was added to the oil and stirred using non-sharp utensils for 2 to 4 minutes. The gelled spirulina/flour mixture was then collected, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina/flour mixture was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Experimental conditions

FLOUR TO BE INCORPORATED	Quantity (%)	Production parameters					
		Mass of	Mass of	Final mass (g)	Quantity of oil (g)	Oil temperature (°C)	Cooking time (min)

		flour (g)	spirulina (g)				
Coconut	5	6	114	120	250	150	4
	20	24	96	120	250	160	3
Lupin	5	6	114	120	250	150	4
	20	24	96	120	250	150	3
Red lentil	5	6	114	120	250	150	4
	20	24	96	120	250	150	2.3
Chickpeas	5	6	114	120	250	150	4
	20	24	96	120	250	150	2
Millet	5	6	114	120	250	150	4
	20	24	96	120	250	150	2
Corn	5	6	114	120	250	150	4
	20	24	96	120	250	150	3
Buckwheat	5	6	114	120	250	150	4
	20	24	96	120	250	160	2

Table 11. Spirulina/flour mixture and treatment conditions

Results

The textured products obtained have an appearance and texture similar to the textured product in Example No. 2 (Figure 15).

- EXAMPLE No. 14 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients - 7% starch

- 250 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 111.6 g fresh spirulina (see Example No. 1)
- 8.4 g potato starch

Ingredients - 12% starch

- 250 g vegetable oil (mixture: rapeseed oil 49%, sunflower oil 41%, linseed oil 6% and high oleic sunflower oil 4%)
- 105.6 g fresh spirulina (see Example No. 1)
- 14.4 g potato starch

Food processor

The mixture of thawed microalgae and starch was prepared using a KitchenAid® food processor (model 5KSM125EER) sold by KitchenAid®.

Method

The oil was preheated at 150°C in a container placed on a hotplate. The spirulina/starch mixture, after undergoing optional heat treatment (approximately 90°C for about 5 minutes), was added to the oil and stirred using non-sharp utensils for a period from 4 minutes (7% starch) or 4.3 minutes (12% starch). The gelled spirulina/starch mixture was then recovered, the excess oil was removed by draining (using a metal mesh filter of approximately 1 mm for approximately 2 minutes) and then blotting (placing the gelled spirulina in contact with absorbent paper for approximately 5 minutes), and the gelled spirulina/starch mixture was placed in the freezer to reach a temperature of -20°C to obtain the textured product of the invention.

Results

The textured products obtained (with or without heat pretreatment of the spirulina/starch mixture) have an appearance and texture similar to the textured product of Example No. 2 (Figure 16, left: 7% starch with pretreatment; right: 12% starch with pretreatment).

- EXAMPLE No. 15 - Manufacture of a textured product according to the invention

Materials & Methods

Ingredients

- 600 g vegetable oil [deodorised organic sunflower oil, Huilerie d'Auron]
- X g fresh spirulina (see Example No. 1).
- Y g co-product from phycocyanin extraction from spirulina

% integration of co-product (CP)	200 g total		pH of mixture	Percentage of moisture in the mixture
	Quantity of co-product (g)	Quantity of spirulina biomass (g)		
5	10	190	6.12	84.53%
15	30	170	6.16	85.68%
30	60	140	6.24	87.91%

Table 12. Co-product/spirulina proportions*Food processor*

The raw material was gelled using a Robot Cook® (sold by Robot Coupe®, reference RR43000R).

5 *Process*

The spirulina biomass and co-product mixtures were prepared in advance according to the quantities in Table 12. Before use, the mixture was completely defrosted in the microwave. The oil was preheated at 135°C in the Robot Cook® (sold by Robot coupe®). The mixture was placed in the Robot Cook® (sold by Robot coupe®) and the contents of the tank were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for a period of 12 to 17 minutes (see Table 13). The gelled spirulina was then recovered using a sieve, and the excess oil was removed by gently pressing it from two layers of kitchen paper. The grains obtained were then placed in a blast freezer at -18°C, then stored in a freezer (-20°C).

% integration of the co-product	Cooking time (min)
5	12
15	15
30	17

15 **Table 13.** Cooking time*Texture measurement*

See Example No. 1

Results

The textured products obtained have a similar appearance and texture to the previously obtained textured product (Figure 17, left 5% co-product; right 30% co-product - Tables 14-15).

Textured product		Hardness (N)	An adhesiveness (N.sec)	An elasticity	A cohesion
CP5%-1	Average	5.81	-0.0097	0.569	0.611
	Standard deviation	2.05	0.0055	0.03	0.021
CP5%-2	Average	12.28	-0.0068	0.771	0.687
	Standard deviation	4.1	0.0056	0.111	0.012
CP15%-1	Average	11.06	-0.007	0.664	0.656
	Standard deviation	4.92	0.0066	0.073	0.024
CP15%-2	Average	4.43	-0.0087	0.628	0.614
	Standard deviation	1.89	0.0042	0.067	0.019
CP30%-1	Average	9.02	-0.0073	0.607	0.661
	Standard deviation	1.69	0.0049	0.011	0.004
CP30%-2	Average	5.81	-0.0097	0.569	0.611

	<i>Standard deviation</i>	2.05	0.0055	0.03	0.021
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Table 14. Texture of textured products obtained

Textured product		Gumminess (N)	A chewiness (N)	A resilience
CP5%-1	Average	3.56	2.02	0.253
	<i>Standard deviation</i>	1.29	0.74	0.014
CP5%-2	Mean	8.45	6.64	0.341
	<i>Standard deviation</i>	2.83	2.75	0.015
CP15%-1	Mean	7.34	4.94	0.304
	<i>Standard deviation</i>	3.45	2.52	0.015
CP15%-2	Average	2.74	1.7	0.274
	<i>Standard deviation</i>	1.25	0.7	0.015
CP30%-1	Average	5.97	3.62	0.306
	<i>Standard deviation</i>	1.11	0.65	0.009
CP30%-2	Average	3.56	2.02	0.253
	<i>Standard deviation</i>	1.29	0.74	0.014

Table 15. Texture of textured products obtained

5 - **EXAMPLE No. 16 - Manufacture of a textured product according to the invention**

Materials & Methods

Ingredients

- 750 g vegetable oil [deodorised organic sunflower oil, Huilerie d'Auron]
- approximately 250 g fresh spirulina (sold by the producers; see Table 16).

Producers	Samples	Moisture content	pH
D	PD02/PD03	83.65%	7.55
G	PG01/PG03	81.92%	5.75
H	PH01/PH03	77.15%	5.92
J	PJ03	74.50%	7.24
L	PL01	77.20%	7.77
M	PM03	72.80%	6.18
N	PN01	82.59%	8.13
O	PO02	80.25%	6.66
P	PP03	79.11%	6.81

Table 16. Suppliers of fresh spirulina

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot Coupe®, reference RR43000R).

Process

- 5 Before processing, the biomass was completely defrosted in the microwave. The oil was preheated at 135°C in the Robot Cook® (sold by Robot coupe®). The biomass was placed in the Robot Cook® (sold by Robot coupe®) and the contents of the tank were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for a period of 11 to 32 minutes (see Table 17). The gelled spirulina was then recovered using a sieve, and the
- 10 excess oil was removed by gently pressing it from two layers of kitchen paper. The grains obtained were then placed in a blast freezer at -18°C, then stored in a freezer (-20°C).

Samples	Weight of raw material (g)	Cooking time (min)
PG01	256	11.5
PG03	246	11.5
PH01	248	11.5
PH03	260	11.5
PD02	251	32
PD03	254	29.5
PA01	254	22
PJ03	233	11
PM01	251.6	12.5
PM03	253.2	15
PL01	253.4	12.5
PN01	246	22.5
PN02	246	27.5
PO02	256	21
PP03	253	21

Table 17. Cooking time

Texture measurement

See Example No. 1

15 Results

The textured products obtained have a similar appearance and texture to the previously obtained textured product (see Tables 18-19).

Textured product		Hardness (N)	An adhesiveness (N.sec)	An elasticity	A cohesion
PG01	Mean	13.9	-0.007	0.7	0.71
	<i>Standard deviation</i>	<i>4</i>	<i>0.004</i>	<i>0</i>	<i>0.01</i>
PG03	Mean	16.187	-0.018	0.636	0.71
	<i>Standard deviation</i>	<i>2.674</i>	<i>0.008</i>	<i>0.028</i>	<i>0.01</i>
PH01	Mean	30.8	-0.019	0.7	0.73

	<i>Standard deviation</i>	13.9	0.012	0.1	0.03
PH03	Mean	31.7	-0.006	0.8	0.71
	<i>Standard deviation</i>	7.6	0.006	0.1	0.01
PI03	Mean	14.3	-0.017	0.7	0.68
	<i>Standard deviation</i>	4.8	0.006	0	0.01
PD02	Mean	29.9	-0.034	0.7	0.69
	<i>Standard deviation</i>	6.99	0.017	0.14	0.03
PD03	Mean	22.9	-0.015	0.6	0.66
	<i>Standard deviation</i>	3.69	0.005	0.01	0.01
PJ03	Mean	22.29	-0.045	0.65	0.6
	<i>Standard deviation</i>	4.88	0.018	0.17	0.02
PL01	Mean	37.09	-0.009	0.78	0.74
	<i>Standard deviation</i>	6.15	0.004	0.05	0.01
PO02	Mean	10.39	-0.081	0.67	0.56
	<i>Standard deviation</i>	3.39	0.023	0.21	0.01
PP03	Mean	24.23	-0.04	0.67	0.63
	<i>Standard deviation</i>	7.4	0.015	0.17	0.02
PN01	Mean	19.73	-0.042	0.6	0.61
	<i>Standard deviation</i>	8.39	0.022	0.11	0.04
PM03	Mean	5.71	-0.141	0.55	0.58
	<i>Standard deviation</i>	2.14	0.071	0.06	0.03

Table 18. Texture of textured products obtained

Textured product		Gumminess (N)	A chewiness (N)	A resilience
PG01	Mean	9.9	7.1	0.35
	<i>Standard deviation</i>	3	2.1	0.01
PG03	Mean	11.437	7.278	0.34
	<i>Standard deviation</i>	1.961	1.269	0.01
PH01	Mean	22.7	16.3	0.38
	<i>Standard deviation</i>	11.1	7.5	0.05
PH03	Mean	22.7	17.2	0.34
	<i>Standard deviation</i>	5.6	5	0.01

PI03	Mean	9.8	7	0.32
	<i>Standard deviation</i>	3.5	2.4	0.02
PD02	Mean	20.8	15.6	0.3
	<i>Standard deviation</i>	5.9	7.92	0.03
PD03	Mean	15.2	9.8	0.28
	<i>Standard deviation</i>	2.68	1.89	0.01
PJ03	Mean	13.52	8.96	0.25
	<i>Standard deviation</i>	3.37	3.65	0.02
PL01	Mean	27.64	21.49	0.37
	<i>Standard deviation</i>	4.9	4.12	0.02
PO02	Mean	5.88	3.97	0.2
	<i>Standard deviation</i>	2.02	1.95	0.01
PP03	Mean	15.46	9.94	0.28
	<i>Standard deviation</i>	5.02	2.78	0.02
PN01	Mean	12.42	7.43	0.24
	<i>Standard deviation</i>	6.31	3.9	0.05
PM03	Mean	3.35	1.87	0.21
	<i>Standard deviation</i>	1.36	0.84	0.02

Table 19. Texture of textured products obtained

- EXAMPLE No. 17 - Manufacture of a textured product according to the invention

Materials & Methods

5 *Ingredients*

- 600 g vegetable oil [deodorised organic sunflower oil, Huilerie d'Auron]
- X g fresh spirulina (see Example No. 1).
- Y g of oat bran fibre

% integration of oat bran (SONA)	200 g total		pH of mixture	Percentage of moisture in the mixture
	Amount of oat bran (g)	Quantity of spirulina biomass (g)		
0% (control)	0	200	8.07	79.90
1	2.5	197.5	8.07	79.90
2	4	196	8.07	79.90
3	6	194	8.07	79.90
4	8	192	8.07	79.90
5	10	190	8.07	79.90

Table 20. Oat bran/spirulina proportions

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R).

Process

5 The spirulina biomass and oat bran mixtures were prepared in advance according to the quantities in Table 20. Before use, the mixture was completely defrosted in the microwave. The oil was preheated at 135°C in the Robot Cook® (sold by Robot coupe®). The mixture was placed in the Robot Cook® (sold by Robot coupe®) and the contents of the tank were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for a period of 10 to 15 minutes (see Table 21). The gelled spirulina was then recovered using a
10 sieve, and the excess oil was removed by gently pressing it from two layers of kitchen paper. The grains obtained were then placed in a blast freezer at -18°C, then stored in a freezer (-20°C).

Samples	Cooking time (min)
SONA1%_1	12
SONA1%_2	14
SONA5%_1	15
SONA2%_1	12
SONA5%_2	10
SONA3%_1	11
SONA4%_1	10
SONA4%_2	11
SONA3%_2	11
SONA2%_2	11
SONA5%_3	11
SONA0%_1	11
SONA0%_2	11

Table 21. Cooking time

15 *Texture measurement*
See Example No. 1

Results

The textured products obtained have a similar appearance and texture to the previously obtained textured product (see Tables 22-23).

Textured product		Hardness (N)	An adhesiveness (N.sec)	An elasticity	A cohesion
SONA0%_1	Mean	9.49	-0.003	0.705	0.647
	Standard deviation	0.916	0.002	0.045	0.011
SONA0%_2	Mean	8.326	-0.01	0.703	0.643
	Standard deviation	0.496	0.004	0.113	0.009
SONA1%_1	Mean	13.393	-0.026	0.629	0.654

	<i>Standard deviation</i>	5.904	0.016	0.023	0.027
SONA1%_2	Mean	11.888	-0.011	0.638	0.631
	<i>Standard deviation</i>	7.207	0.005	0.022	0.024
SONA2%_1	Mean	9.347	-0.019	0.673	0.633
	<i>Standard deviation</i>	1.705	0.009	0.113	0.016
SONA2%_2	Mean	14.638	-0.014	0.741	0.639
	<i>Standard deviation</i>	4.232	0.006	0.139	0.013
SONA3%_1	Mean	18.314	-0.01	0.684	0.638
	<i>Standard deviation</i>	5.11	0.005	0.079	0.019
SONA3%_2	Mean	14.273	-0.009	0.68	0.616
	<i>Standard deviation</i>	5.955	0.006	0.033	0.018
SONA4%_1	Mean	4.654	-0.018	0.557	0.561
	<i>Standard deviation</i>	1.319	0.012	0.043	0.017
SONA4%_2	Mean	8.272	-0.015	0.61	0.6
	<i>Standard deviation</i>	1.007	0.006	0.036	0.007
SONA5%_1	Mean	8.797	-0.016	0.579	0.586
	<i>Standard deviation</i>	5.297	0.01	0.053	0.028
SONA5%_2	Mean	16.927	-0.01	0.644	0.627
	<i>Standard deviation</i>	3.888	0.007	0.072	0.011

Table 22. Texture of textured products obtained

Textured product		Gumminess (N)	A chewiness (N)	A resilience
SONA0%_1	Mean	6.148	4.323	0.268
	<i>Standard deviation</i>	0.666	0.438	0.01
SONA0%_2	Mean	5.359	3.759	0.263
	<i>Standard deviation</i>	0.372	0.6	0.004
SONA1%_1	Mean	8.871	5.627	0.283
	<i>Standard deviation</i>	4.18	2.763	0.018
SONA1%_2	Mean	7.647	4.865	0.28
	<i>Standard deviation</i>	4.993	3.154	0.022
SONA2%_1	Mean	5.935	4.005	0.251
	<i>Standard deviation</i>	1.177	0.997	0.01

SONA2%_2	Mean	9.401	7.008	0.265
	<i>Standard deviation</i>	<i>2.898</i>	<i>2.542</i>	<i>0.011</i>
SONA3%_1	Mean	11.761	8.139	0.25
	<i>Standard deviation</i>	<i>3.58</i>	<i>2.487</i>	<i>0.013</i>
SONA3%_2	Mean	8.879	6.032	0.242
	<i>Standard deviation</i>	<i>3.98</i>	<i>2.697</i>	<i>0.014</i>
SONA4%_1	Mean	2.626	1.476	0.213
	<i>Standard deviation</i>	<i>0.823</i>	<i>0.538</i>	<i>0.011</i>
SONA4%_2	Mean	4.97	3.036	0.236
	<i>Standard deviation</i>	<i>0.656</i>	<i>0.451</i>	<i>0.006</i>
SONA5%_1	Mean	5.269	3.054	0.228
	<i>Standard deviation</i>	<i>3.369</i>	<i>1.948</i>	<i>0.014</i>
SONA5%_2	Mean	10.64	6.971	0.259
	<i>Standard deviation</i>	<i>2.577</i>	<i>2.456</i>	<i>0.012</i>

Table 23. Texture of textured products obtained

- EXAMPLE No. 18 - Manufacture of a textured product according to the invention

Materials & Methods

5 *Ingredients*

- 600 g vegetable oil [deodorised organic sunflower oil, Huilerie d'Auron]
- X g fresh spirulina (see Example No. 1).
- Y g buckwheat flour

% buckwheat flour (SAR)	200 g total		pH of mixture	Percentage of moisture in the mixture
	Quantity of buckwheat flour (g)	Quantity of spirulina biomass (g)		
0% (control)	0	200	6.715	84.8
1	2.5	197.5	6.715	84.8
2	4	196	6.715	84.8
3	6	194	6.715	84.8
4	8	192	6.715	84.8
5	10	190	6.715	84.8

10 **Table 24.** Oat bran/spirulina proportions

Food processor

The raw material was gelled using a Robot Cook® (sold by Robot coupe®, reference RR43000R).

Process

The spirulina biomass and oat bran mixtures were prepared in advance according to the quantities in Table 20. Before use, the mixture was completely defrosted in the microwave. The oil was preheated at 135°C in the Robot Cook® (sold by Robot coupe®). The mixture was placed in the Robot Cook® (sold by Robot coupe®) and the contents of the tank were stirred by a double blade rotating in opposite directions (anti-clockwise) at a speed of -100 rpm for 10 minutes. The gelled spirulina was then collected with a sieve, and the excess oil was removed by gently pressing it from two layers of kitchen paper. The resulting grains were finally placed in a blast freezer at -18°C, then stored in a freezer (-20°C).

10 Texture measurement

See Example No. 1

Results

The textured products obtained have a similar appearance and texture to the previously obtained textured product (see Tables 25-26).

Textured product	Hardness (N)	An adhesiveness (N.sec)	An elasticity	A cohesion
SAR0%_1	10.279	-0.007	0.662	0.687
SAR0%_2	14.764	-0.002	0.732	0.682
SAR1%_1	11.082	-0.006	0.682	0.693
SAR1%_2	9.518	-0.01	0.676	0.675
SAR2%_1	7.702	-0.004	0.671	0.671
SAR2%_2	6.544	-0.009	0.615	0.615
SAR3%_1	6.036	-0.003	0.684	0.66
SAR3%_2	6.699	-0.004	0.698	0.644
SAR4%_1	3.993	-0.003	0.675	0.609
SAR4%_2	5.827	-0.006	0.636	0.615
SAR5%_1	7.044	-0.005	0.55	0.572
SAR5%_2	5.93	-0.007	0.537	0.569

15 **Table 25.** Texture of textured products obtained

Textured product	Gumminess (N)	A chewiness (N)	A resilience
SAR0%_1	7.061	4.67	0.321
SAR0%_2	10.1	7.383	0.29
SAR1%_1	7.694	5.245	0.316
SAR1%_2	6.423	4.329	0.315
SAR2%_1	5.202	3.519	0.272
SAR2%_2	4.004	2.456	0.259
SAR3%_1	3.996	2.735	0.282
SAR3%_2	4.313	3.015	0.275
SAR4%_1	2.44	1.649	0.248
SAR4%_2	3.597	2.291	0.249

SAR5%_1	4.033	2.228	0.205
SAR5%_2	3.384	1.811	0.204

Table 26. Texture of textured products obtained

CLAIMS

1. Textured product comprising:
 - at least 50% by weight of at least one gelled microalgae and/or at least one of its gelled derivatives, relative to the total weight of said textured product; and
 - 5 ▪ at least 5% by weight of oil relative to the total weight of said textured product, said textured product having a moisture content from 13% to 71% and being in the form of grains with an average particle size from 2 mm to 10.5 mm, said textured product having the following properties:
 - a hardness from 2.5 N to 369 N in a texture analysis using a texturometer;
 - 10 ▪ a resilience from 0.016 to 0.46 in a texture analysis using a texturometer; and
 - a cohesion from 0.090 to 0.76 in a texture analysis using a texturometer.

2. Textured product according to claim 1, said textured product further having:
 - an elasticity from 0.20 to 1 in a texture analysis using a texturometer; and/or
 - 15 ▪ a chewiness from 0.23 N to 110 N in a texture analysis using a texturometer; and/or
 - a gumminess from 1 N to 111 N in a texture analysis using a texturometer.

3. Textured product according to claim 1 or 2, said at least one gelled microalgae being
 - 20 selected from: spirulina, chlorella, klamath and mixtures thereof; and/or said at least one of its gelled derivatives, being a co-product resulting from the industrial processing of at least one microalgae, in particular said at least one of its derivatives being a co-product of pigment extraction such as phycocyanin.

4. Textured product according to any of claims 1 to 3, wherein said at least one gelled
 - 25 microalgae and said at least one of its derivatives are mixed, the mass ratio [*gelled microalgae:one of its gelled derivatives*,] being from [1:5] to [5:1].

5. Textured product according to any of claims 1 to 4, said oil being a vegetable oil selected
 - 30 in particular from: sunflower oil, high oleic sunflower oil, deodorised sunflower oil, frying sunflower oil, virgin coconut oil, deodorised virgin coconut oil, rapeseed oil, olive oil, peanut oil, linseed oil and mixtures thereof.

6. Textured product according to any of claims 1 to 5, said textured product further
 - 35 comprising at least 5% by weight, relative to the total weight of said textured product, of a flour selected in particular from: wheat flour, coconut flour, lupin flour, red lentil flour, chickpea flour, millet flour, corn flour, buckwheat flour and mixtures thereof;

and/or a fibre selected in particular from: apple fibre, oat bran fibre, rice bran fibre, wheat bran fibre and mixtures thereof; and/or a starch, in particular potato starch.

- 5 **7.** Process for preparing the textured product according to any of claims 1 to 6, said process comprising at least the steps of:
 - i) gelling at a temperature from 120°C to 160°C for a period from 5 minutes to 10 minutes of at least one microalgae and/or at least one of its derivatives in an oil previously heated at a temperature from 120°C to 160°C, said gelation being
 10 carried out with stirring using non-cutting means, to obtain at least one gelled microalgae in the form of grains and/or at least one of its derivatives gelled in the form of grains;
 15 ii) recovering said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains;
 20 iii) optionally removing excess oil present in said at least one gelled microalgae in the form of grains and/or said at least one of its gelled derivatives in the form of grains to obtain at least one gelled microalgae, optionally free of excess oil, in the form of grains and/or at least one of its gelled derivatives, optionally free of excess oil, in the form of grains; and
 25 iv) cooling said at least one gelled microalgae, optionally free of excess oil, in the form of grains and/or said at least one of its gelled derivatives, optionally free of excess oil in the form of grains, so that it and/or they reach(es) a temperature lower than or equal to 4°C to obtaining the aforementioned textured product according to any of claims 1 to 6.
- 30 **8.** Process for preparing according to claim 7, wherein said at least one microalgae and/or said at least one of its derivatives is introduced into said oil in a mass ratio [*at least one microalgae and/or at least one of its derivatives: oil*] of [1:0.15] to [1:5].
- 35 **9.** Process for preparing according to claim 7 or 8, wherein, in step i), said at least one microalgae and/or said at least one of its derivatives has a pH from 5.5 to 8.5 and a moisture content from 40% to 93%, said at least one microalgae and/or said at least one of its derivatives having, in particular, the following properties:
 - 40 ▪ a hardness from 0.95 N to 1.052 N in a texture analysis using a texturometer;
 - an adhesiveness from -3.631 N.sec to -2.887 N.sec in a texture analysis using a texturometer;
 - an elasticity from 8.988 to 9.012 in a texture analysis using a texturometer;
 - a cohesion ranging from 0.657 to 0.777 in a texture analysis using a texturometer;
 - a chewiness ranging from 0.56 N to 0.738 N in a texture analysis using a texturometer; and
 -

▪ a resilience of 0.008 in a texture analysis using a texturometer, and said at least one microalgae and/or said at least one of its derivatives having optionally undergone, prior to step i), a freezing step followed optionally by a thawing step.

- 5 **10.** Use of the textured product according to any of claims 1 to 6 as a textured protein ingredient for the manufacture of a human or animal food product,
- 10 in particular for manufacturing:
- a meat substitute, such as minced beef, sausage, or meatballs;
 - a ready-made dish, such as shepherd's pie, Bolognese sauce, chilli con carne, and maki;
 - a pastry, such as a chocolate cake,
- 15 said textured product having a moisture content from 30% to 71%;
- or for making a *topping*, said textured product having a moisture content from 13% to 25%;
- 15 or for manufacturing animal feed, said textured product having a moisture content from 13% to 20%.