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(71) **Applicant** (for all designated States except AE, AG, AU, BB, BH, BN, BW, BZ, CA, CY, EG, GB, GD, GH, GM, IE, IL, IN, KE, KN, KW, LC, LK, LS, MT, MW, MY, NA, NG, NZ, OM, PG, QA, RW, SA, SC, SD, SG, SL, SZ, TT, TZ, UG, US, VC, ZA, ZM, ZW): **UNILEVER N.V.** [NL/NL]; Weena 455, 3013 AL Rotterdam (NL).

(71) **Applicant** (for AE, AG, AU, BB, BH, BN, BW, BZ, CA, CY, EG, GB, GD, GH, GM, IE, IL, IN, KE, KN, KW, LC, LK, LS, MT, MW, MY, NA, NG, NZ, OM, PG, QA, RW, SA, SC, SD, SG, SL, SZ, TT, TZ, UG, VC, ZA, ZM, ZW only): **UNILEVER PLC** [GB/GB]; a company registered in England and Wales under company no. 41424 of Unilever House, 100 Victoria Embankment, London Greater London EC4Y 0DY (GB).

(71) **Applicant** (for US only): **CONOPCO, INC., D/B/A UNILEVER** [US/US]; 800 Sylvan Avenue AG West, S. Wing, Englewood Cliffs, New Jersey 07632 (US).

(72) **Inventors**: **BENJAMIN, Mia, Claire**; Unilever R&D Vlaardingen B.V. Olivier van Noortlaan 120, 3133 AT Vlaardingen (NL). **VAN DER HIJDEN, Hendrikus, Theodorus, W., M.**; Unilever R&D Vlaardingen B.V. Olivier van Noortlaan 120, 3133 AT Vlaardingen (NL). **KHALLOUFI, Seddik**; Unilever R&D Vlaardingen B.V. Olivier van Noortlaan 120, 3133 AT Vlaardingen (NL). **VREEKER, Robert**; Unilever R&D Vlaardingen B.V. Olivier van Noortlaan 120, 3133 AT Vlaardingen (NL).

(74) **Agent**: **FIJNVANDRAAT, Arnoldus C.**; Unilever Patent Group, Olivier van Noortlaan 120, 3133 AT Vlaardingen (NL).

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(54) **Title**: PROCESS OF PREPARING A FOODSTUFF WITH WATER-DISPERSIBLE POWDER CONTAINING DEHULLED PULSE SEED COMPONENT

(57) **Abstract**: The present invention relates to a process of preparing a foodstuff comprising mixing a water-dispersible powder with aqueous liquid and optionally with other food ingredients, said water-dispersible powder comprising 30-100 wt.% of dehulled pulse seed (DPS) component and 0-70 wt.% of carrier material, said DPS component containing 30-60 wt.% gelatinized starch and 15-35 wt.% pulse protein; wherein the combination of the DPS component and the carrier material constitutes at least 90 wt.% of the powder; wherein the water-dispersible powder has an oil content of at least 0.2 wt.%; wherein at least 80 wt.% of the particles contained in the powder have a diameter in the range of 10-1,000 µm; and wherein at least 90 vol.% of the water-insoluble constituents has a hydrated diameter of less than 150 µm.



PROCESS OF PREPARING A FOODSTUFF WITH WATER-DISPERSIBLE POWDER CONTAINING DEHULLED PULSE SEED COMPONENT

5 TECHNICAL FIELD OF THE INVENTION

The present invention relates to a water-dispersible powder comprising dehulled pulse seed component, said dehulled pulse seed component containing 30-60 wt.% gelatinized starch and 15-35 wt.% pulse protein. More particularly, the invention relates
10 to the use of such water-dispersible powders in the preparation of foodstuffs.

The water-dispersible powder can be produced by a method comprising:

- providing an aqueous suspension containing ground dehulled pulse seeds
- heating the aqueous suspension to gelatinize the starch contained therein
- 15 • homogenizing the heated suspension, and
- drying the homogenized suspension.

BACKGROUND OF THE INVENTION

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It is known in the art to use pulse flour, e.g. lentil flour in the preparation of oil-and-water emulsions.

WO 2012/089448 describes an edible oil-in-water emulsion comprising 0.1- 8% of
25 finely ground pulse seed, calculated as dry matter by weight of aqueous phase

WO 2012/089448 describes the preparation of a mayonnaise having an oil content of 50 wt.% by a procedure that comprises:

- milling lentils in a grinder to produce flour having a mass weighted average particle
30 size of appr 40 μm and less than 1 wt.% particles larger than 120 μm ;
- mixing the lentil flour into cold water;
- heating to 90-95°C for 30 minutes;
- cooling to 30-40°C;

- adding sugar, salt and oil while mixing with a Silverson mixer;
- adjusting pH with vinegar.

WO 2014/095180 describes a method of preparing an oil-in-water emulsion, said
5 method comprising combining oil, water, heat-treated pulse flour, native pulse flour and optionally further ingredients. Example 1 of WO 2014/095180 describes the preparation of a heat-treated brown lentil flour by pressure cooking the flour at low moisture, followed by air drying and milling. The starch in the flour was not gelatinized as a result of this heat treatment. The same example also describes the preparation of heat-
10 treated red lentil flour by means of extrusion, wherein the starch was gelatinized during the extrusion. Example 4 describes the preparation of lentil flour from whole lentils by cooking the lentils in salt water to gelatinize the starch, cooling in tap water, followed by air drying, milling and sieving. The same example also describes the preparation of a dried flour by cooking an aqueous slurry of lentil flour at 90°C for 30 minutes, followed
15 by drum drying at 120°C, grinding and sieving.

WO 2014/095324 describes tea-based beverages comprising pre-gelatinized lentil flour. Example 2 describes a ready-to-drink tea-based beverage that contains a pre-gelatinized flour that had been prepared by spray drying a pre-gelatinized lentil slurry.

20

WO 2014/001030 describes an oil-in-water emulsion containing gelatinized starch, pulse seed albumin and a polysaccharide thickener selected from xanthan gum, pectin (DE>40) and combinations thereof.

Example 4 describes the preparation of a mayonnaise by the following procedure:

- 25
- disperse lentil flour into cold demineralised water
 - heat the lentil flour slurry to 85°C for 5 minutes.
 - cool down to 60°C
 - prepare an aqueous xanthan gum solution (1 wt.%)
 - introduce the lentil slurry in a Silverson mixer.
- 30
- add the 1 % xanthan gum solution, NaCl, sugar and oil whilst mixing
 - homogenize the emulsion in a high pressure homogenizer at 250 bar.
 - introduce homogenized emulsion in Silverson mixer and add vinegar and stabilized egg yolk

WO 2016/062567 describes foamable aqueous food products having a triglyceride content of 0-0.02 wt.% that contain defatted lentil flour. Example 1 describes the preparation of a defatted lentil flour by spray drying a homogenized aqueous dispersion of lentil flour, followed by extraction with hexane.

5

Spray dried pulse seed flours have also been described in the prior art.

Bakker *et al.* (*Production of instant bean powders*, Nutritional aspects of common beans and other legume seeds as animal and human foods, Proceedings of a meeting
10 held November 6-9, 1973, Ribeirao, Brazil, editore: W.G. Jaffé) describes a the preparation of a lentil flour by:

- soaking and cooking lentils for 30 min at 210°F, followed by retorting for 30 min at 230°F;
- wet-milling in a pulper with 0.065 and 0.023 inc sieve openings; and
- 15 • spray-drying in horizontal concurrent-type drier.

Cryne *et al.* (*Spray-dried pulse consumption does not affect cardiovascular disease risk or glycemic control in healthy males*, Food Research International 48 (2012) 131-139) describes the preparation of spray dried lentil flour by:

- 20 • cooking lentils for 90-105 minutes;
- mixing and homogenizing with an Urschel cutter and microcut Stephan homogenizer.
- preheating in vertical tubular heat exchanger to 35-40°C;
- drying in fast-spouted INTERJET bed dryer.

25

Ma *et al.* (*Rheological, physical stability, microstructural and sensory properties of salad dressing supplemented with raw and thermally treated lentil flours*, Journal of Food Engineering 116 (2013) 862-872). This article describes the preparation of a heat treated lentil flour by cooking lentil seeds at 95°C or 30 minutes, followed by spray
30 drying with an Atomizer spray dryer or freeze drying, grinding (three times) with a knife grinder (Stephan Microcut Type MC15) and sieving over a sieve with 425 µm openings.

SUMMARY OF THE INVENTION

The inventors have developed a water-dispersible powder comprising dehulled pulse seed component that has excellent emulsion stabilizing properties. The water-dispersible powder of the present invention can be obtained, for instance, by heating an aqueous suspension of ground dehulled pulse seeds to gelatinize the starch, followed by intense homogenization and drying. Unlike WO 2016/062567, the water-dispersible powder of the present invention is not defatted to remove triglycerides.

Although the inventors do not wish to be bound by theory it is believed that the high intensity homogenization effectively minimizes the formation of crystalline amylose and/or crystalline amylopectin during drying. The inventors have generated experimental data showing that the presence of crystalline amylose/amylopectin hinders dissolution of water-soluble components that have emulsion stabilizing properties. The water-dispersible powder of the present invention can advantageously be used in the preparation of foodstuffs as it can easily be dispersed and because of its emulsion stabilizing properties.

Accordingly, the present invention provides a process of preparing a foodstuff comprising mixing a water-dispersible powder with aqueous liquid and optionally with other food ingredients, said water-dispersible powder comprising dehulled pulse seed (DPS) component and optionally carrier material, said DPS component containing 30-60 wt.% gelatinized starch and 15-35 wt.% pulse protein; wherein the water-dispersible powder has an oil content of at least 0.2 wt.%; wherein at least 80 wt.% of the particles contained in the powder have a diameter in the range of 10-1,000 μm ; and wherein at least 90 vol.% of the water-insoluble constituents has a hydrated diameter of less than 150 μm .

DETAILED DESCRIPTION OF THE INVENTION

The invention relates to a process of preparing a foodstuff comprising mixing a water-dispersible powder with aqueous liquid and optionally with other food ingredients, said
5 water-dispersible powder comprising 30-100 wt.% of dehulled pulse seed (DPS) component and 0-70 wt.% of carrier material, said DPS component containing 30-60 wt.% gelatinized starch and 15-35 wt.% pulse protein;
wherein the combination of the DPS component and the carrier material constitutes at least 90 wt.% of the powder;
10 wherein the water-dispersible powder has an oil content of at least 0.2 wt.%;
wherein at least 80 wt.% of the particles contained in the powder have a diameter in the range of 10-1,000 μm ; and
wherein at least 90 vol.% of the water-insoluble constituents has a hydrated diameter of less than 150 μm .

15

The term "starch" as used herein, unless indicated otherwise, refers to native, non-modified, starch. Starch consists of two types of molecules: the linear and helical amylose and the branched amylopectin.

20 The term "gelatinized starch" as used herein refers to starch that has undergone gelatinization. Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites to engage more water. This irreversibly dissolves the starch granule. Penetration of water increases randomness in the general starch granule structure and
25 decreases the number and size of crystalline regions. Under the microscope in polarized light starch loses its birefringence and its extinction cross during gelatinization. Some types of unmodified native starches start swelling at 55°C, other types at 85°C. The gelatinization temperature depends on the degree of cross-linking of the amylopectin.

30

The term "protein" as used herein refers to a linear polypeptide comprising at least 10 amino acid residues.

The term "denatured protein" refers to protein that has lost or changed its native three-dimensional structure, involving the (partial) loss of quaternary structure, tertiary structure and/or secondary structure.

- 5 The term "albumin" as used herein refers to a protein that is soluble in water and in moderately concentrated salt solutions and that experiences heat coagulation.

The term "globulin" as used herein refers to a protein that is insoluble in water, but soluble in saline solutions.

10

- The term "pulse" as used herein refers to an annual leguminous crop yielding from one to twelve seeds of variable size, shape, and colour within a pod and is reserved for crops harvested solely for the dry seed. This excludes fresh green beans and fresh green peas, which are considered vegetable crops. Also excluded are crops that are
- 15 mainly grown for oil extraction (oilseeds like soybeans and peanuts), and crops which are used exclusively for sowing (clovers, alfalfa). Just like words such as "bean" and "lentil", the word "pulse" may also refer to just the seed, rather than the entire plant.

- The term "oil" as used herein refers to lipids selected from the group of triglycerides, diglycerides, monoglycerides, phospholipids and free fatty acids. The term "oil"
- 20 encompasses lipids that are liquid at ambient temperature as well as lipids that are partially or wholly solid at ambient temperature. The term "phospholipid" as used herein refers to a lipid comprising a glycerol bound to one or two fatty acids and a phosphate group.

25

The term "dietary fiber" as used herein refers to indigestible non-starch polysaccharides such as arabinoxylans, cellulose, lignin, pectins and beta-glucans.

The term "sugars" as used herein refers to mono- and disaccharides.

30

The diameter of the particles in the water-dispersible powder can be determined by light microscopy. A random sample of the powder is sprinkled on a microscope slide and the particles are allowed to position themselves. The slide is placed under the

microscope and a particle to be measured is chosen randomly. Particle diameter is calculated as the diameter of the smallest circumscribed circle. The procedure is repeated a number of times to obtain a representative particle size distribution.

Reference: M.E. Houghton and G.E. Amidon, *Microscopic characterization of particle size and shape: an inexpensive and versatile method*, Pharmaceutical Research, Vol. 5 9, No. 7, pp. 856-859 (1992).

The hydrated diameter of the water-insoluble constituents of the water-dispersible powder can be determined by laser diffraction. This technique measures particle size 10 distributions by recording the angular variation in intensity of light scattered from a laser beam passing through a particle dispersion. Small particles scatter light at large angles relative to the laser beam whereas large particles scatter light at small angles. The angular scattering intensity data is analyzed to calculate the size of the particles, using the Mie theory of light scattering. Particle sizes are reported as a volume equivalent 15 sphere diameters. Reference: ISO 13320-1 Particle size analysis – Laser Diffraction Methods Part 1: General Principles (1999). Particle size distributions can be measured on a Malvern Mastersizer 2000 (Malvern Instruments Ltd, UK), equipped with a hydro 2000S aqueous dispersion system containing approximately 150 ml demineralised water. The water is continuously circulated through a flow cell. A few drops of an 20 aqueous dispersion of the water dispersible powder (prepared at 20°C, concentration 10 wt%) are pipetted into the sample dispersion unit until the prescribed obscuration is obtained. The samples are measured without ultrasonic pulsing.

The water-dispersible powder of the present invention contains dehulled pulse seed 25 (DPS) component. The hulls of pulse seed predominantly consist of dietary fibre. Dietary fibre originating from the seed hulls was found to adversely affect the functionality of the powder as an emulsion stabilizing agent.

The water-dispersible powder typically contains at least 10 wt.%, more preferably 20- 30 60 wt.% and most preferably 30-55 wt.% gelatinized starch.

Typically, at least 80 wt.%, more preferably at least 90 wt.% and most preferably at least 95 wt.% of the starch in the water-dispersible powder is gelatinized starch.

The amount of pulse protein in the water-dispersible powder typically is at least 5 wt.%, more preferably 10-35 wt.% and most preferably 15-33 wt.%. Advantageously, essentially all the pulse protein in the water-dispersible powder is in a denatured state. The amount of denatured pulse protein in the water-dispersible powder typically is at
5 least 5 wt.%, more preferably 10-35 wt.% and most preferably 15-33 wt.%.

Gelatinized starch and denatured pulse protein typically represent the bulk of the DPS component. Together, gelatinized starch and denatured pulse protein preferably represent at least 40 wt.%, more preferably at least 50 wt.% and most preferably 60-85
10 wt.% of the DPS component.

Other components, i.e. components other than gelatinized starch and pulse protein, that may be contained in the DPS component include dietary fiber, sugars, oil and water.
15

The DPS component typically contains at least 1 wt.% water-soluble nitrogen and at least 10 wt.% water-soluble carbon. More preferably, the DPS component contains at least 1.1 wt.%, most preferably at least 1.2 wt.% of water-soluble nitrogen. Water-soluble carbon is preferably contained in the DPS component in a concentration of at
20 least 14 wt.%, more preferably of at least 18 wt.% and most preferably of at least 20 wt.%.

The concentrations of water-soluble nitrogen and water-soluble carbon are determined as follows:

- 25
- 25 gram DPS component is dispersed in 225 gram Millipore water at 20°C;
 - the dispersion is equilibrated for 4 hours and periodically shaken (manually);
 - the dispersion is centrifuged at 10.000×g for 45 minutes (T = 20°C), e.g. in a Beckman Coulter Avanti J-262 XP centrifuge;
 - the supernatant phase is collected and analysed for total nitrogen and total carbon
30 content.

Total nitrogen and total carbon are determined using the Dumas method. The sample is introduced into a combustion chamber which is heated to 900 °C. An excess quantity

of pure oxygen is added directly to the sample to completely combust it into carbon dioxide, nitrogen and water. The water is removed from the system by an osmosis system, chemical drying and a water condenser. A column separates the carbon dioxide from the nitrogen gasses. Detection of the gasses is done using a Thermal
5 Conductivity Detector (TCD).

Gelatinized starch and denatured pulse protein are preferably contained in the water-dispersible powder in a weight ratio of 1:2 to 5:1 , more preferably of 2:3 to 3:1 and most preferably of 1:1 to 5:2.

10

The water-dispersible powder typically contains less than 25%, most preferably less than 20% of dietary fiber.

The sugar content of the water-dispersible powder preferably is in the range of 0.5-70
15 wt.%, more preferably in the range of 0.8-40 wt.%, most preferably in the range of 1-12 wt.%.

The oil content of the water-dispersible powder preferably does not exceed 12 wt.%. More preferably, the oil content is in the range of 0.2-10 wt.%, even more preferably in
20 the range of 0.3-8 wt.% and most preferably in the range of 0.8-5 wt.%.

Typically, starch, dietary fiber, sugars, pulse protein and oil together make up at least 30 wt.%, more preferably at least 60 wt.% and most preferably at least 80 wt.% of the water-dispersible powder.

25

Globulins and albumins typically represent a major part of the protein contained in the powder. Accordingly, in a preferred embodiment, globulins and albumins represent at least 50 wt.%, more preferably 55-95 wt.% and most preferably 60-90 wt.% of the protein contained in the water-dispersible powder. Powders with very good emulsion
30 stabilizing properties contain globulins and albumins in a weight ratio that lies within the range of 1 0:1 to 1 :1 , or even more preferably in a weight ratio of 7:1 to 2:1 .

In accordance with another preferred embodiment the globulins legumin and vicilin together represent at least 35 wt.%, more preferably 40-75 wt.% and most preferably 45-70 wt.% of the protein comprised in the powder.

- 5 The content of globulin, albumin, legumin, vicilin, and glutelin in the powder is suitably determined by the method described by Gupta & Dhillon [Gupta, R., & Dhillon, S. 1993. Characterization of seed storage proteins of Lentil (*Lens culinaris* M.). *Annals of Biology*, 9, 71 -78].
- 10 The pulse seed component is advantageously obtained from a pulse selected from lentils, chickpeas, beans and combinations thereof. Even more preferably, the pulse seed component is obtained from a pulse selected from lentils, chickpeas, mung beans and combinations thereof. Most preferably, the pulse seed component is obtained from lentils.
- 15 The water-dispersible powder of the present invention may suitably contain up to 70 wt.% of a carrier material. Preferably, the carrier material is water-soluble, i.e. the carrier material has a water solubility of at least 15 grams per 100 ml of distilled water at 20°C.
- 20 The carrier material is preferably selected from the group consisting of monosaccharides, disaccharides, trisaccharides, maltodextrin, pectin and combinations thereof. Most preferably, the carrier material is maltodextrin.
- 25 The water-dispersible powder preferably contains not more than 50 wt.% of the carrier material. More preferably the powder contains less than 30 wt.%, even more preferably less than 10 wt.% carrier material. Most preferably, the water-dispersible powder does not contain carrier material and consists of the DPS component.
- 30 The water-dispersible powder of the present invention is particularly effective as an emulsion stabilizing agent if it forms a gel when 12 grams of the powder are dispersed in 100 ml demineralized water having a temperature of 20°C. Even more preferably,

the powder forms a gel when 8 grams of the powder are dispersed in 100 ml demineralized water having a temperature of 20°C.

5 The water-dispersible powder typically has a bulk density of 0.10-0.40 g/ml. More preferably, the bulk density of the powder is in the range of 0.10-0.20 g/ml.

It was found that the water-dispersible powder of the present invention has unusual foaming properties. Typically, when dispersed into cold demineralized water at a concentration of 10 wt.% the water-dispersible powder can be whipped to produce a foam with an overrun of at least 100%, which foam loses less than 50%, preferably less
10 than 30% and most preferably less than 20% of said overrun when the foam is kept at 20°C for 12 hours.

The special physical properties of the water-dispersible powder are also demonstrated by the presence of not more than a very limited amount of crystalline starch (amylose
15 and/or amylopectin). Typically, less than 5 wt.% of the starch contained in the powder is in crystalline form. More preferably, less than 3 wt.% , even more preferably less than 2 wt.%, even more preferably less than 1 wt.% and most preferably less than 0.5 wt.% of the starch is in crystalline form. The percentage of starch that is in crystalline form can be determined by means of X-ray diffraction using, for instance, the
20 procedure described by Klug and Alexander, *X-ray diffraction procedures for polycrystalline and amorphous materials*, 2nd ed., John Wiley, New York and London (1974).

25 The particle size distribution of the water-dispersible powder is dependent, for instance, on the drying technique that is applied during manufacture.

In one preferred embodiment, the water-dispersible powder is obtained by spray drying and is composed of relatively small particles. Accordingly, in a preferred embodiment, at least 80 wt.% of the particles contained in the water-dispersible powder have a
30 diameter in the range of 20-500 µm, more preferably in the range of 30-400 µm, more preferably in the range of 50-300 µm.

In another preferred embodiment, the water-dispersible powder is obtained by drum drying and is composed of relatively large particles. Accordingly, in a preferred embodiment, at least 80 wt.% of the particles contained in the water-dispersible powder have a diameter in the range of 400-1,000 μm , more preferably in the range of 450-900 μm , more preferably in the range of 500-800 μm .

The inventors have found that the water-dispersible powder of the present invention has particularly good emulsion stabilizing properties if at least 90 vol.% of the water-insoluble constituents has a hydrated diameter of less than 120 μm , more preferably of 20-100 μm and most preferably of 50-90 μm . Gelatinized starch preferably represents the bulk, most preferably at least 60 wt.% of these water-insoluble constituents.

In accordance with another preferred embodiment, the water-insoluble constituents of the water-dispersible powder have a volume weighted average hydrated diameter of less than 80 μm , more preferably of 20-70 μm and most preferably of 30-60 μm .

In accordance with a preferred embodiment, the water-dispersible powder that is employed in the present process is obtained by a method comprising:

- a) providing an aqueous suspension containing 5-30 wt.% of ground dehulled pulse seeds,
- b) heating the aqueous suspension to gelatinize the starch contained therein;
- c) homogenizing the heated suspension to produce a homogenized suspension containing suspended starch particles, said suspended starch particles having a volume weighted mean diameter of less than 2 μm , and
- d) drying the homogenized suspension to a water content of less than 10 wt.%.

The pulse seeds employed in the aforementioned method are preferably selected from lentils, chickpea, bean and combinations thereof. Most preferably, the pulse seed employed is lentils.

In order to gelatinize the starch, the aqueous suspension is typically heated in step b) to at least 80°C. for at least 5 minutes, preferably for at least 15 minutes. The heating time needed to gelatinize the starch is dependent on the heating temperature. The

higher the heating temperature, the shorter the heating time that is required to achieve gelatinization.

Homogenization of the heated suspension in step c) may be achieved in different ways.

5 Preferably, the heated suspension is homogenized by one or more homogenization devices selected from high pressure homogenizers, high speed dispensers (e.g. Ultra Turrax dispensers ex IKA GmbH, Germany) and microfluidizers. Most preferably, the heated suspension is homogenized by high pressure homogenization.

10 According to a particularly preferred embodiment the heated suspension is homogenized using a high pressure homogenizer at a pressure of at least 180 bar, more preferably of at least 300 bar and most preferably of at least 500 bar.

The homogenized suspension obtained by homogenization typically has a dry matter
15 content of 5-35 wt.%. More preferably, the dry matter content is in the range of 8-20 wt.%, most preferably of 10-16 wt.%.

The homogenized suspension is preferably dried in step d) by means of spray drying, e.g. spray drying in the presence of gas such as nitrogen or CO₂; drum drying; freeze
20 drying or a combination of these drying techniques. More preferably, the homogenized suspension is dried by means of spray drying, drum drying or a combination of these drying techniques. Most preferably, the homogenized suspension is dried by means of spray drying.

25 Spray drying of the homogenized suspension is preferably done in a spray dryer by atomizing the suspension into a spray drying chamber through a nozzle, using a pressure drop of 2-50 bar.

The homogenized suspension is preferably dried in the spray dryer by atomizing the
30 suspension into a spray drying chamber and contacting the atomized suspension within said chamber with a stream of hot drying gas. The hot drying gas typically has a temperature of at least 150-210°C, more preferably of 160-190°C when it enters the

spray drying chamber. The outlet temperature of the gas preferably is less than 120°C, more preferably 50-100°C.

According to a particularly preferred embodiment, the present process is used to
5 prepare a foodstuff in the form of an oil-in-water emulsion, more preferably an oil-in-water emulsion containing 20-85 wt.% of dispersed fat phase and 15-80 wt.% of continuous aqueous phase.

Examples of oil-in-water emulsions according to the present invention include
10 mayonnaise, dressings, soups, sauces and drinks. Preferably, the present emulsion is a dressing or a mayonnaise. Most preferably, the emulsion is a mayonnaise.

The invention also concerns the foodstuffs that are obtained by the present process.

15 The invention is further illustrated by the following non-limiting examples.

EXAMPLES

Example 1

Dried powders were prepared from lentil flour using different pretreatment and drying regimens as shown in Table 1.

Table 1

Sample	Pretreatments	Drying technique	Drying conditions
1	High pressure Homogenisation	Spray drying	190°C
2		Drum drying	130°C and high speed of the drum
3		Drum drying	90°C and low speed of the drum
A	No high pressure homogenization	Spray drying	195°C
B		Jet Spouted Bed drying	108°C
C		Jet Spouted Bed drying	114°C
D		Freeze drying	

All samples were produced by first preparing a slurry of red lentil flour in water. These slurries were cooked at 95°C for 20 min (starch gelatinization) in a double jacketed vessel under gentle stirring.

The cooked slurries 1, 2 and 3 were subjected to high pressure homogenization (1 pass at 500 bar) before drying.

Before drying, the cooked slurries A, B, and C were mixed with a colloid mill at low speed for 40 minutes to prevent phase separation. Cooked slurry A was additionally mixed for 30 minutes using a lab homogenizer (type Silverson) at low speed, again to prevent phase separation.

The slurries were dried using the different drying techniques mentioned in Table 1.

The emulsification properties of the dried powders so obtained were evaluated using the following procedure:

- 5 gram lentil powder was added to 82.2 gram cold tap water and blended for 30 seconds using a hand-held blender (Braun, 300 Watt).
 - 4 gram sucrose and 2.8 g NaCl were added to the mixture.
 - 100 g soybean oil (at room temperature) was slowly added to the mixture whilst mixing with a hand-blender, taking about 60-75 seconds. Blending continued until a full 2 minutes was reached.
 - The emulsion so obtained was acidified to pH 3.7 using 12% acetic acid.
 - The acidified emulsion was blended for a further 30 seconds.
- The final composition of the emulsions is shown in Table 2.

Table 2

Ingredient	w/w %	Weight (g)
Lentil powder	2.5	5
Water (tap, cold)	41.1	82.2
Salt (NaCl)	1.4	2.8
Sugar (sucrose)	2.0	4.0
Oil (Soybean oil)	50	100
Vinegar (12% acetic acid)	3.0	6.0
Total	100	200

- Appearance and stability of the emulsions were visually evaluated after 3 days storage at 20 °C.

The foaming properties of the dried powders were evaluated as follows:

- 225 g of cold tap water was poured into the mixing bowl of a Kenwood food mixer (Titanium Timer Chef KM030, Kenwood UK) equipped with a five wire whisk attachment.
- 25 g of lentil powder was dispersed in the water while whisking at low speed (speed dial at position 1) during 1 minute.
- A foam was prepared by whipping the dispersion at maximum speed during 15 minutes.
- Overrun of the samples was calculated as follows: overrun (%) = $100 \times (V_{\text{foam}} - V_0) / V_0$, where V_{foam} is volume of whipped sample and V_0 is initial sample volume before whipping.

The results of these evaluations are summarized in Table 3.

Table 3

Sample	Emulsion appearance	Overrun after		Foam appearance
		0 hours	10 hours	
1	Homogeneous, spoonable	466	466	Homogeneous, small bubbles
2	Homogeneous, pourable	545	545	Homogeneous, small bubbles
3	Homogeneous, pourable	511	511	Homogeneous, small bubbles
A	Phase separated	39	<10	Inhomogeneous, large bubbles
B	Phase separated	19	<10	Inhomogeneous, large bubbles
C	Phase separated	n.a.	n.a.	No foam
D	Phase separated	19	<10	Inhomogeneous, large bubbles

The firmness of the emulsion samples (after 3 days storage at 20 °C) was assessed by Stevens value measurements. 170 g of sample was contained in a 200 ml glass jar (ca. 61mm diameter). The Stevens hardness (St), expressed in grams, was determined at 20°C, using a typical mayonnaise grid in a Stevens LFRA Texture Analyzer (ex. Stevens Advanced Weighing Systems, UK) with a maximum load/measuring range of 1000 grams and by applying a penetration depth of 25 mm at 2 mm/s penetration rate. The mayonnaise grid comprises square openings of approximately 3x3 mm, consisting of wire with a thickness of approximately 1 mm. Samples A-D were gently stirred with a spoon prior to the measurements.

Storage moduli (G') and viscosity (η) of the emulsion samples were measured using a TA Instruments AR 2000 EX rheometer equipped with a plate-cone geometry (cone: 4 cm diameter, 2 degree angle). Moduli were determined in oscillatory mode at a frequency of 1 Hz in a stress interval from 0.1 to 1768 Pa (stress sweep). G' (Pa) was taken as the low-stress plateau value (linear region). Viscosity (η) was recorded at a constant shear rate (50 s⁻¹) after shearing for 10 seconds. All measurements were performed at 20 °C. Samples A-D were gently stirred with a spoon prior to the measurements as these samples had phase separated, i.e. a cream layer of oil droplets had formed on top of the sample and an aqueous layer at the bottom of the sample.

The results of these evaluations (average of 3 measurements) are summarized in Table 4.

Table 4

Sample	Stevens value (g)	G' (Pa)	η (Pa.s)
1	55	562	1.69
2	21	355	1.59
3	19	307	1.40
A	< 3	27	0.05
B	< 3	1	0.06
C	< 3	2	0.05
D	< 3	6	0.05

Example 2

The dried powders described in Example 1 were analyzed by means of light microscopy.

To this end the dried powders were dispersed in cold water (concentration ca. 1 wt%) and examined using a light microscope. Clear differences were observed between the powders that had been produced from homogenized slurries (samples 1-3) and those that were produced from non-homogenized slurries (samples A-D). At high magnification the particles of the dried powders produced from non-homogenized slurries display an internal structure, i.e. these particles appear to be composed of smaller, more or less globular particles (diameter 20-30 μm). The globular particles are tightly packed and surrounded by a layer of starch or cellulosic material. Such an internal structure is not observed for the dried powders that had been prepared from high pressure homogenized slurries (1, 2, and 3).

The dried powders were also examined under a light microscope with crossed polarizers. Again clear differences were observed between on the one hand the powders obtained from homogenized slurries and on the other hand those obtained from non-homogenized slurries. Particles from non-homogenized dried powders appeared bright under crossed polarizers, especially near the particle edges, suggesting the presence of anisotropic or crystalline regions. Particles from homogenized dried powders, on the other hand, appeared completely black, indicating absence of crystalline regions.

Example 3

X-ray diffraction experiments were performed to determine the level of crystallinity in the dried powders of Example 1. Measurements were done using a D8 Discover x-ray diffractometer (ex Brücker AXS).

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The dried powders prepared from non-homogenized slurries (powders A to D) showed sharp diffraction peaks characteristic for crystalline amylose and/or amylopectin, superimposed on a broad background signal arising from amorphous starch. By contrast, the dried powders prepared from homogenized slurries (powders 1 to 3) did not show any sharp diffraction peaks indicating the absence of crystalline starch. Peak areas and background signal were analyzed and used to calculate the ratio of crystalline to non-crystalline starch. The results are shown in Table 5.

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Table 5

Sample	% crystallinity
1	0
2	0
3	0
A	11
B	7
C	6
D	10

15

Example 4

The solubilizing behavior of the dried powders of Example 1 was investigated. To this end 25 grams of dried powders were dispersed in 225 grams of Millipore water at 20°C.

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The dispersions were equilibrated for 4 hours and periodically shaken (manually). After equilibration pH of the dispersions varied between 6.4 and 6.9.

The dispersions were transferred to a Beckman Coulter Avanti J-262 XP centrifuge and centrifuged at 10.000×g for 45 minutes (T = 20 °C). Resulting pellet phases containing undissolved starches, proteins and cell wall material were discarded. The clear supernatant phases (containing soluble protein and starch) were collected and analyzed for total dissolved nitrogen and carbon content. The results are shown in Table 6.

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Table 6

Sample	pH	Protein in supernatant (g/100 g)	Carbon in supernatant (g/100 g)
1	6.40	1.2	3.0
2	6.45	0.8	2.2
3	6.45	0.8	2.4
A	6.97	0.2	0.4
B	6.66	0.5	0.8
C	6.63	0.5	0.7
D	6.61	0.5	0.7

The aforementioned supernatant samples were stored in a fridge at 5 °C. Initially, all supernatant samples were transparent and liquid like. After several days, the supernatant phases of samples 1 to 3 had become translucent and hazy. These samples were no longer pourable and had turned into weak gels. In contrast thereto, the supernatant phases of samples A to D were still transparent and liquid-like.

Example 5

A spray dried powder was prepared in the same way as sample 1 of Example 1, except that the spray dried powder was agglomerated during spray drying by recycling the fines into the Multi Stage Dryer.

Next, the emulsification and foaming properties of the agglomerated powder were investigated, the % crystallinity was determined, and the concentrations of water soluble nitrogen and carbon were analyzed, using the procedures described herein before. The results are summarized in Table 7.

Table 7

Emulsifying properties	
• Stevens value (g)	53
• G' (Pa)	532
• Viscosity (Pa.s)	1.65
• appearance	Homogeneous, spoonable
Foaming properties	
• overrun after 0 hours	504%
• overrun after 10 hours	504%
• appearance	Homogeneous, small bubbles
% crystallinity	0%

Water-soluble protein and carbon	
• pH (10% dispersion)	6.38
• Protein in supernatant (g/100 g)	0.9
• Carbon in supernatant (g/100 g)	2.4

Claims

1. A process of preparing a foodstuff comprising mixing a water-dispersible powder with aqueous liquid and optionally with other food ingredients, said water-dispersible powder comprising 30-100 wt.% of dehulled pulse seed (DPS) component and 0-70 wt.% of carrier material, said DPS component containing 30-60 wt.% gelatinized starch and 15-35 wt.% pulse protein;
wherein the combination of the DPS component and the carrier material constitutes at least 90 wt.% of the powder;
wherein the water-dispersible powder has an oil content of at least 0.2 wt.%;
wherein at least 80 wt.% of the particles contained in the powder have a diameter in the range of 10-1,000 μm ; and
wherein at least 90 vol.% of the water-insoluble constituents has a hydrated diameter of less than 150 μm .
2. Process according to claim 1, wherein the foodstuff is an oil-in-water emulsion, preferably an oil-in-water emulsion containing 20-85 wt.% of dispersed fat phase and 15-80 wt.% of continuous aqueous phase.
3. Process according to claim 1 or 2, wherein the foodstuff is selected from mayonnaise, dressings, soups, sauces and drinks.
4. Process according to any one of the preceding claims, wherein the DPS component is obtained from lentils, chickpeas, beans or a combination thereof.
5. Process according to any one of the preceding claims, wherein the DPS component is obtained from lentils.
6. Process according to any one of the preceding claims, wherein the water-dispersible powder has an oil content of at least 0.3-8 wt.%, more preferably of 0.8-5 wt.%.
7. Process according to any one of the preceding claims, wherein the water-dispersible powder contains 20-60 wt.%, preferably 30-55 wt.% gelatinized starch.

8. Process according to any one of the preceding claims, wherein the water-dispersible powder contains 10-35 wt.%, preferably 15-33 wt.% pulse protein.
9. Process according to any one of the preceding claims, wherein the carrier material is selected from the group consisting of monosaccharides, disaccharides, trisaccharides, maltodextrin, pectin and combinations thereof.
10. Process according to any one of the preceding claims, wherein the water-dispersible powder contains not more than 50 wt.% carrier material, preferably less than 30 wt.% carrier material, more preferably less than 10 wt.% carrier material.
11. Process according to claim 10, wherein the water-dispersible powder consists of the DPS component.
12. Process according to any one of the preceding claims, wherein less than 5 wt.% of the starch is in crystalline form, as determined with X-ray diffraction.
13. Process according to any one of the preceding claims, wherein the DPS component contains at least 1 wt.% water-soluble nitrogen and at least 10 wt.% water-soluble carbon.
14. Process according to any one of the preceding claims, wherein at least 80 wt.% of the particles contained in the water-dispersible powder have a diameter in the range of 20-500 μm
15. Process according to any one of the preceding claims, wherein the water-dispersible powder is obtained by a method comprising:
 - a) providing an aqueous suspension containing 5-30 wt.% of ground dehulled pulse seeds,
 - b) heating the aqueous suspension to gelatinize the starch contained therein;
 - c) homogenizing the heated suspension to produce a homogenized suspension containing suspended starch particles, said suspended starch particles having a volume weighted mean diameter of less than 2 μm , and
 - d) drying the homogenized suspension to a water content of less than 10 wt.%.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/063098

A. CLASSIFICATION OF SUBJECT MATTER
INV. A23L11/00 A23L27/60
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A23L A23D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016/062567 A1 (UNILEVER NV [NL]; UNILEVER PLC [GB]; CONOPCO INC DBA UNILEVER [US]) 28 April 2016 (2016-04-28) cited in the application page 1, lines 7-12 page 4, line 4 - page 5, line 10 page 9, lines 29-31 page 10, line 4 - page 11, line 4 page 11, line 28 - page 12, line 1 page 12, lines 16-19 example 1 ----- -/--	1-10, 12, 13, 15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Piret-Viprey, E

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/063098

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	WO 00/22939 A2 (BASIC AMERICAN INC [US]; CAMIN HENRY J [US]; JOHNSON LAWRENCE G [US];) 27 April 2000 (2000-04-27) the whole document -----	1-4,7,8, 11,13,15
A	ZHEN MA ET AL: "Thermal processing effects on the functional properties and microstructure of lentil, chickpea, and pea flours", FOOD RESEARCH INTERNATIONAL, ELSEVIER, AMSTERDAM, NL, vol. 44, no. 8, 6 December 2010 (2010-12-06), pages 2534-2544, XP028270962, ISSN: 0963-9969, DOI: 10.1016/J.FOODRES.2010.12.017 [retrieved on 2010-12-16] page 2534, last paragraph - page 2535, paragraph 1 page 2535, left-hand column, paragraph 2 page 2535, paragraphs 2.1,2.2,2.3,2.5 page 2536, paragraph 2.6.4-2.6.7 page 2537, left-hand column, last paragraph - right-hand column, paragraph 1 figure 2 page 2540, paragraph 3.4.5 - page 2541, paragraph 3.4.6 page 2543, left-hand column, paragraph 2 -----	1-15
A	WO 2014/095324 A1 (UNILEVER NV [NL]; UNILEVER PLC [GB]; CONOPCO INC DBA UNILEVER [US]) 26 June 2014 (2014-06-26) cited in the application page 1, lines 6-18 page 2, line 31 - page 3, line 27 page 7, lines 20-26 page 8, line 21- page 9, lines 16-28 page 9, line 33 - page 10, line 26 example 2 ----- -/--	1-15

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/063098

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE INSPEC [Online] THE INSTITUTION OF ELECTRICAL ENGINEERS, STEVENAGE, GB; June 2013 (2013-06), ZHEN MA ET AL: "Rheological, physical stability, microstructural and sensory properties of salad dressings supplemented with raw and thermally treated lentil flours", XP002764554, Database accession no. 14085449 cited in the application abstract -& JOURNAL OF FOOD ENGINEERING, vol. 116, no. 4, 8 February 2013 (2013-02-08), pages 862-872, XP002765080, ELSEVIER SCIENCE LTD. UK ISSN: 0260-8774, DOI: 10.1016/J.JFOODENG.2013.01.024 page 863, left-hand column, paragraph 3 - right-hand column, paragraph 1 page 872, left-hand column, last paragraph -----	1-15
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International application No

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