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DESCRIPTION

[0001] The present invention relates to a process for the production of discrete solid extruded particles comprising dispersion droplets, to such particles as well as to the use of such particles in food, feed, pharmaceutical and personal care applications.

[0002] The invention is defined by the appended claims.

[0003] The dispersions which are extruded are solid lipophilic active-in-water-dispersions comprising at least one carotenoid and at least one emulsifying protective colloid and water.

[0004] The terms "emulsion" and "dispersion" in the context of the present invention are synonyms. A dispersion in the context of the present invention comprises (at least) one (or more) carotenoid and one (or more) emulsifier and water.

[0005] There are many ways to formulate carotenoids. The types of formulations are depending i.e. on the use of these formulations in the final application as well as on the kind of material (ingredients) which are used. However, the most important and demanding formulations are the so-called dried dispersions. The carotenoid is emulsified into an aqueous phase containing a matrix material and/or a suitable emulsifying protective colloid. After drying, the carotenoid is embedded in the matrix material. It is possible that the carotenoid is (partially) crystallised in the extrudate.

[0006] Known technologies for dispersions are e.g. rotor-stator-systems, high pressure homogenizers or ultrasonic devices. A major disadvantage of these technologies is that a relatively low viscosity (usually below 1 Pas) is required, leading to high amounts of water in the dispersion. Usually these processes require the use of an organic solvent which has to be removed after dispersion or precipitation.

[0007] Extrusion processes (and extruders) are well known in the field of formulations. They can be used for many different kinds of materials. They can be used for many different kinds of materials, such as thermoplastics and rubbers, as well as food-and feedstuffs.

[0008] The main advantages of using the extrusion technology is that high viscous solutions can be formulated and less water can be used for the dispersion, which then requires less drying. Furthermore an extrusion process can be run as a continuous process and it can be run without organic solvents.

[0009] It can be found in the prior art that emulsions comprising fat soluble vitamins are extruded. US 2004/0201116 discloses pellets which are obtained by a combination of producing emulsions using devices like high pressure homogenizers with subsequent direct pelleting or extrusion as a second process step. WO 2006/066389 discloses dry particulate encapsulation composition comprising water-insoluble matrix containing proteins and moisture

content; and an encapsulate such as beta-carotene.

[0010] The goal of the present invention was to find a way to improve (also simplify) the production of extrudates comprising solid lipophilic active-in-water-dispersion droplets comprising at least one carotenoid and at least one emulsifying protective colloid and water.

[0011] These extrudates should then also be formed into a good flowable form which has a low fraction of the solid lipophilic active-in-water-dispersion droplets on the particle surface.

[0012] Carotenoids are distinctly different from lipophilic vitamins and lipophilic flavours. These lipophilic vitamins are either liquid or can easily be made liquid by using reasonable temperatures well below 100°C. Carotenoids are lipophilic, cannot be melted around 100°C, and decompose at higher temperatures. They are classical representative of the so-called sparingly soluble lipophilic actives.

[0013] A new way for the production of such discrete solid particles was found. Surprisingly it was found out that when the dispersion process is carried out inside the extruder, and then afterward the extrudates are further formed into discrete solid particles, the process as well as the obtained extrudates and discrete solid particles are improved.

[0014] When the dispersion process is carried out in the extruder (extrusion apparatus), and wherein afterward the extrudates are further formed into discrete solid extruded particles,

1. (i) very small average dispersion droplets sizes can be obtained, and
2. (ii) a very narrow and monomodal distribution of the droplet sizes is obtained, and
3. (iii) such a process can easily be run as a continuous process, and
4. (iv) no organic solvent is used and
5. (v) less water can be used and therefore less energy for drying the extrudate is necessary, and
6. (vi) good flowability of the discrete solid extruded particles.

[0015] Therefore the present invention relates to a process of production of discrete solid extruded particles having a particle size of less than 1000 µm, preferably less than 700 µm, more preferably between 50 - 700 µm, wherein an extrudate comprising solid lipophilic active-in-water-dispersion ingredient droplets, wherein said dispersion comprises at least one carotenoid and at least one emulsifying protective colloid and water, is produced by extrusion in a first step, and after the extrusion the extrudate is further formed into discrete solid extruded particles, wherein the carotenoid is β-carotene, and wherein β-carotene is added to the process as a solid powder premixed with at least one modified (food) starch.

[0016] The emulsifying process is carried out in the extruder.

[0017] A preferred embodiment of the present invention relates to a process as described

above wherein the extrudate is further formed into discrete solid extruded particles by cutting and drying.

[0018] A preferred embodiment of the present invention relates to a process as described above wherein the drying can be carried out before cutting, during the cutting or after the cutting, as well as a combination thereof (=any sequence of drying and cutting).

[0019] A preferred embodiment of the present invention relates to a process as described above wherein the extrudate is further formed into discrete solid extruded particles by a spheronisation process.

[0020] At least modified starch as emulsifying protective colloid is used in the process according to the present invention. The term emulsifying protective colloid cover all protective colloids having emulsifying properties. Any commonly known and used emulsifying protective colloid can be used in addition to modified starch. The emulsifying protective colloid can be chosen depending on the final use of the extrudate afterwards. That means if the extrudate obtained by the process according to the present invention is used in food or feed product, the emulsifying protective colloid must be food or feed grade. And in case it is used in pharmaceutical application the emulsifier must be pharma grade.

[0021] Suitable emulsifying protective colloids are i.e. modified (food) starches, ascorbyl palmitate, pectin, alginate, carrageenan, furcellaran, dextrin derivatives, celluloses and cellulose derivatives (e.g. cellulose acetate, methyl cellulose, hydroxypropyl methyl cellulose), lignosulfonate, polysaccharide gums (such as gum acacia (= gum arabic), flaxseed gum, ghatti gum, tamarind gum and arabinogalactan), gelatine (bovine, fish, pork, poultry), plant proteins (such as are for example peas, soybeans, castor beans, cotton, potatoes, sweet potatoes, manioc, rapeseed, sunflowers, sesame, linseed, safflower, lentils, nuts, wheat, rice, maize, barley, rye, oats, lupin and sorghum), animal proteins including milk or whey proteins, lecithin, polyglycerol ester of fatty acids, monoglycerides of fatty acids, diglycerides of fatty acids, sorbitan ester, PG ester and sugar ester (as well as derivatives thereof).

[0022] The starches can be modified physically and chemically. Pregelatinized starches are examples of physically modified starches. Acidic modified, oxidized, cross-linked, starch esters, starch ethers and cationic starches are examples of chemically modified starches.

[0023] Water is also used in the process according to the present invention. But as mentioned before, it is possible to run the process with less water when compared to the usually used processes.

[0024] No organic solvent is used in the process according to the present invention.

[0025] It is also possible to add further ingredients (auxiliary agents) during the process of formulation (extrudation).

[0026] Such auxiliary agents can be useful for the extrusion process and/or for the extrudate, and/or for the discrete solid particles, and/or for the product (or application), wherein the discrete solid particles are used afterwards.

[0027] Such auxiliary agents are for example *antioxidants* (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural)), butylated hydroxytoluene (BHT), ascorbyl palmitate, butylated hydroxyanisole (BHA), propyl gallate, tert. butyl hydroxyquinoline, ethoxyquin and/or ascorbic acid esters of a fatty acid); *plasticisers* (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); *stabilisers* (such as gel-forming agents as xanthan gum, gellan gum); *humectants* (such as glycerine, sorbitol, polyethylene glycol); *dyes*; *fragrances*; *fillers* and *buffers*.

[0028] These auxiliary agents are added optionally. When added then the amount of the auxiliary agents goes from 1 to 85 weight-% (wt.-%), based on the total weight of the dispersion.

[0029] All the preferences listed above for the emulsifying protective colloids and the auxiliary agents also apply to the composition of the extrudates as well as to the discrete solid extruded particles.

[0030] In a preferred process according to the present invention 0.5 wt.-% to 50 wt.-%, preferably 1 wt.-% to 45 wt.-%, more preferably 1 wt.-% to 30 wt.-%, even more preferably 1 wt.-% to 20 wt.-%, especially preferably 1 wt.-% to 15 wt.-%, based on the total weight of the dispersion, of at least one carotenoid are used.

[0031] In a preferred process according to the present invention 5 wt.-% to 80 wt.-%, more preferably 8 wt.-% to 80 wt.-%, even more preferably 10 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of at least one emulsifying protective colloid are used.

[0032] In a preferred process according to the present invention 1 wt.-% to 90 wt.-%, more preferably 1 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of water are used.

[0033] In a preferred process according to the present invention 1 wt.-% to 85 wt.-%, based on the total weight of the dispersion, of at least one auxiliary agent are used.

[0034] Therefore a preferred embodiment of the present disclosure relates a process of production of discrete solid extruded particles, wherein an extrudate comprising solid lipophilic active-in-water-dispersion droplets is produced by extrusion in a first step, wherein said

dispersion comprises

0.5 wt.-% to 50 wt.-%, based on the total weight of the dispersion, of at least one carotenoid, and

5 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of at least one emulsifying protective colloid, and

1 wt.-% to 90 wt.-%, based on the total weight of the dispersion, of water and

1 wt.-% to 85 wt.-%, based on the total weight of the dispersion, of at least one auxiliary agent, and

wherein after the extrusion the extrudate is further formed into discrete solid extruded particles.

[0035] Therefore a preferred embodiment of the present disclosure relates to a process of production of discrete solid extruded particles, wherein an extrudate comprising solid lipophilic active-in-water-dispersion droplets is produced by extrusion in a first step,

wherein said dispersion comprises

1 wt.-% to 45 wt.-%, based on the total weight of the dispersion, of at least one carotenoid chosen from the group consisting of α -carotene, β -carotene, 8'-apo- β -carotenal, 8'-apo- β -carotenoic acid esters such as the ethyl ester, canthaxanthin, astaxanthin, lycopene, lutein, zeaxanthin and crocetin, and

8 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of at least one emulsifying protective colloid chosen from the group consisting of modified (food) starches, ascorbyl palmitate, pectin, alginate, carrageenan, furcellaran, dextrin derivatives, celluloses and cellulose derivatives (e.g. cellulose acetate, methyl cellulose, hydroxypropyl methyl cellulose), lignosulfonate, polysaccharide gums (such as gum acacia (= gum arabic), flaxseed gum, ghatti gum, tamarind gum and arabinogalactan), gelatine (bovine, fish, pork, poultry), plant proteins (such as are for example peas, soybeans, castor beans, cotton, potatoes, sweet potatoes, manioc, rapeseed, sunflowers, sesame, linseed, safflower, lentils, nuts, wheat, rice, maize, barley, rye, oats, lupin and sorghum), animal proteins including milk or whey proteins, lecithin, polyglycerol ester of fatty acids, monoglycerides of fatty acids, diglycerides of fatty acids, sorbitan ester, PG ester and sugar ester (as well as derivatives thereof), and

1 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of water and

1 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of at least one auxiliary agent chosen from the group consisting of antioxidants (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural); butylated hydroxytoluene (BHT); butylated hydroxyanisole (BHA); ascorbyl palmitate; propyl gallate; tert. butyl hydroxyquinoline, ethoxyquin, and/or ascorbic acid esters of a fatty acid); plasticisers (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); stabilisers (such as gel-forming agents as xanthan gum, gellan gum); humectants (such as glycerine, sorbitol, polyethylene glycol); dyes; fragrances; fillers and buffers, and

wherein after the extrusion the extrudate is further formed into discrete solid extruded particles.

[0036] Therefore a more preferred embodiment of the present disclosure relates to a process of production of discrete solid extruded particles, wherein an extrudate comprising solid lipophilic active-in-water-dispersion droplets is produced by extrusion in a first step,

wherein the dispersion comprises

1 wt.-% to 30 wt.-%, preferably 1 wt.-% to 20 wt.-%, more preferably 1 wt.-% to 15 wt.-%, based on the total weight of the dispersion, of β -carotene, and

10 wt.-% to 80 wt.-%, based on the total weight of the dispersion, of at least one (modified) food starch, and

1 to 60 wt.-%, based on the total weight of the dispersion, of water and

1 to 80 wt.-%, based on the total weight of the dispersion, of at least one auxiliary agent chosen from the group consisting of antioxidants (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural); butylated hydroxytoluene (BHT); butylated hydroxyanisole (BHA); ascorbyl palmitate; propyl gallate; tert. butyl hydroxyquinoline, ethoxyquin, and/or ascorbic acid esters of a fatty acid); plasticisers (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); stabilisers (such as gel-forming agents as xanthan gum, gellan gum); humectants (such as glycerine, sorbitol, polyethylene glycol); dyes; fragrances; fillers and buffers, and

wherein after the extrusion the extrudate is further formed into discrete solid extruded particles.

[0037] One of the advantages of the present invention is that the size distribution of the average droplet sizes of the solid lipophilic active-in-water-dispersion inside the extrudate (and in the discrete solid extruded particles) is narrow and monomodal. This means that the carotenoid is nearly homogeneously distributed inside the extrudate (and in the discrete solid extruded particles), which allows afterwards very precise dosages.

[0038] Furthermore, the process according to the present invention allows to producing very small sized droplets of the solid lipophilic active-in-water-dispersion inside the extrudate (and in the discrete solid extruded particles). The average droplet size can be as small as 50 nm. Usually the droplets are smaller than 1 μ m.

[0039] Preferably the average droplet size ($d_{3,2}$) of the solid lipophilic active-in-water-dispersion the extrudate (and in the discrete solid extruded particles) is between 50 nm and 300 nm.

[0040] The droplet sizes are measured by using commonly known and standardized methods. Suitable methods are light scattering or laser diffraction.

[0041] More preferably the average droplet size ($d_{3,2}$) of the solid lipophilic active-in-water-dispersion inside the extrudate (and in the discrete solid extruded particles) is between 100 nm and 200 nm.

[0042] The extrusion process is characterised in that the dispersion process is carried out inside the extruder. Usually the three main ingredients (carotenoid and emulsifying protective colloid and water) are added at different inlets of the extruder process.

[0043] These inlets are arranged separated from each other. When (optionally) auxiliary

agents are added, they can be added together with one or more of the main ingredients or they can also be added in a separate step.

[0044] Usually the emulsifying protective colloid is added first, then the water and then the carotenoid is added. It is also possible that one ingredient is added through more than one inlet of the extruder at different locations. Therefore a further embodiment of the present invention relates to a process, wherein the emulsifying protective colloid (or a mixture of emulsifiers) is added first, then the water and then afterwards the carotenoid (or a mixture of carotenoids).

[0045] The temperature inside the extruder is usually between 20 and 220 °C. Preferably the temperature of extrudate exiting the extruder is < 100 °C. The total residence time for the ingredients in the extruder is usually between 1 and 400 s.

[0046] The amount of shear of the extrusion process according to the present invention is usually 200 to 80000 units.

Furthermore, it is also possible to pump inert gas through the extruder. The inert gas is usually pumped in at the entrance of the extruder. But it could also be pumped in at any stage of the extrusion process (also through several inlets at different locations). Inert gas can be helpful to protect sensible ingredients.

[0047] The extruder comprises usually one or more screw shafts on which various conveying or kneading type screw elements are mounted.

[0048] The material is transported by these elements through the extruder (optionally under pressure and elevated temperature). At the end (exit) of the extruder there can be a die through which the extruded material is pressed. Afterwards the extruded material is dried and cut (or also vice versa). The extruder can have several inlets through which the material can be added.

[0049] In the case of the present invention there are several inlets to add the emulsifier(s), the carotenoid(s), water and optionally the auxiliary agents.

[0050] An essential feature of the present invention is that the extrudate is (after the extrusion process) further formed into discrete solid extruded particles.

This forming step can be carried out by using various processes.

It is suitable to carry out this forming step by cutting and drying the extrudate. The drying can be carried out before cutting, during the cutting or after the cutting, as well as any other combination thereof.

The cutting can be carried out by any known device used in the extruder technology. The cutting conditions are related to the desired size of the discrete solid extruded particles.

[0051] The drying can be carried out by any known device. The drying conditions are related to the desired size and desired final water content of the discrete solid extruded particles.

[0052] It is also suitable to carry out this forming step by a spheronisation process. The spheronisation process ("spheronisation") is a known process. During spheronisation cylindrical extrudate strands are converted into spherical, solid particles. In this process, the extrudate strands are broken down into segments and then rounded until they have the desired shape. Finally they are discharged from the spheroniser and transferred to an optional drying step to obtain the final water content in the pellets.

[0053] The present invention also relates to discrete solid extruded particles obtainable by a process (as described above), wherein the discrete solid extruded particles comprise solid lipophilic active-in-water-dispersion droplets, wherein these dispersion droplets comprise at least carotenoid and at least one emulsifying protective colloid and water, characterised in that after the extrusion the extrudate is further formed into the discrete solid extruded particles, and wherein the dispersion process is carried out in the extruder.

[0054] All the preferences as described above also apply for such discrete solid extruded particles obtainable by the inventive process.

[0055] A further embodiment of the present invention relates to new discrete solid extruded particles. These inventive discrete solid extruded particles comprise solid lipophilic active-in-water-dispersion droplets which have a very small average droplet size, and wherein the distribution of the droplet sizes is narrow and (almost) monomodal.

[0056] The particle sizes of the discrete solid extruded particles are lower than 1000 μm . preferably lower than 700 μm . Usually between 50 - 700 μm .

[0057] It is also possible to produce discrete solid extruded particles having a particle size between 50 - 500 μm or having a particle size between 100 - 400 μm .

[0058] The particle size distribution of the discrete solid extruded particles is quite narrow.

[0059] The shape of the discrete solid extruded particles is preferably spherical.

[0060] The particle size and shape are determined by using well known methods, such as optical microscopy, (scanning) electron microscopy or laser diffraction (only for size). The particle size in the context of the present invention is defined as the longest dimension of a particle (such i.e. the diameter in case of spherical particle or in case of non-spherical particles the diameter of an equivalent sphere).

[0061] A further embodiment of the present disclosure relates to discrete solid extruded particles comprising solid lipophilic active-in-water-dispersion droplets, wherein these dispersion droplets comprise
at least one carotenoid and
at least one emulsifying protective colloid, and

water, and optionally at least one auxiliary agent, characterised in that the average particle size of the solid lipophilic active-in-water-dispersion droplets inside the discrete solid extruded particles are less than 300 nm (preferably the average particle size of the solid lipophilic active-in-water-dispersion droplets is between 100 nm and 200 nm), characterised that the discrete solid extruded particles comprise less than 10 wt-%, based on the total weight of the discrete solid extruded particles, of water (preferably less than 6 wt-%).

[0062] The average particle sizes of the solid lipophilic active-in-water-dispersion droplets are measured by laser diffraction, e.g. with a Malvern Mastersizer 2000 and Hydro 2000 S sample dispersion unit. The average particle size of the solid lipophilic active-in-water-dispersion droplets can also be determined by dynamic light scattering, e.g. with a Malvern Zetasizer Nano.

[0063] Preferred discrete solid extruded particles according to the present disclosure comprise:

0.5 wt.-% to 50 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one carotenoid, and
5 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one emulsifying protective colloid, and
less than 10 wt.-%,	based on the total weight of the discrete solid extruded particles, of water and optionally
1 wt.-% to 85 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one auxiliary agent,

characterised in that the average particle sizes of the solid lipophilic active-in-water-dispersion droplets inside the discrete solid extruded particles are less than 300 nm (preferably the average particle sizes of the solid lipophilic active-in-water-dispersion droplets are between 100 nm and 200 nm).

[0064] The particle sizes of these discrete solid extruded particles are lower than 1000 µm. preferably lower than 700 µm. Usually between 50 - 700 µm.

[0065] More preferred are discrete solid extruded particles comprising

1 wt.-% to 45 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one carotenoid chosen from the group consisting of α- carotene, β- carotene, 8'-apo-β-carotenal, 8'-apo-β-carotenoic acid esters such as the ethyl ester, canthaxanthin, astaxanthin, lycopene, lutein, zeaxanthin and crocetin, and
8 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one emulsifying protective colloid chosen from the group consisting of modified (food) starches, ascorbyl palmitate, pectin, alginate, carrageenan, furcellaran, dextrin derivatives, celluloses and cellulose derivatives (e.g. cellulose acetate, methyl cellulose, hydroxypropyl methyl

	cellulose), lignosulfonate, polysaccharide gums (such as gum acacia (= gum arabic), flaxseed gum, ghatti gum, tamarind gum and arabinogalactan), gelatine (bovine, fish, pork, poultry), plant
	proteins (such as are for example peas, soybeans, castor beans, cotton, potatoes, sweet potatoes, manioc, rapeseed, sunflowers, sesame, linseed, safflower, lentils, nuts, wheat, rice, maize, barley, rye, oats, lupin and sorghum), animal proteins including milk or whey proteins, lecithin, polyglycerol ester of fatty acids, monoglycerides of fatty acids, diglycerides of fatty acids, sorbitan ester, PG ester and sugar ester (as well as derivatives thereof), and
less than 6 wt.-%,	based on the total weight of the discrete solid extruded particles, of water, and
1 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one auxiliary agent, wherein the auxiliary agent is chosen from the group consisting of antioxidants (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural)), butylated hydroxytoluene (BHT), ascorbyl palmitate, butylated hydroxyanisole (BHA), propyl gallate, tert. butyl hydroxyquinoline, ethoxyquin and/or ascorbic acid esters of a fatty acid); plasticisers (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); stabilisers (such as gel-forming agents as xanthan gum, gel-lan gum); humectants (such as glycerine, sorbitol, polyethylene glycol); dyes; fragrances; fillers and buffers,

characterised in that the average particle size of the solid lipophilic active-in-water-dispersion droplets inside the discrete solid extruded particles is less than 300 nm (preferably the average particle size of the solid lipophilic active-in-water-dispersion droplets is between 100 nm and 200 nm) and wherein the particle sizes of the discrete solid extruded particles are lower than 1000 μm (preferably lower than 700 μm , more preferably between 50 - 700 μm).

[0066] Further more preferred are discrete solid extruded particles comprising

1 wt.-% to 30 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one carotenoid chosen from the group consisting of α -carotene, β -carotene, 8'-apo- β -carotene, 8'-apo- β -carotenoic acid esters such as the ethyl ester, canthaxanthin, astaxanthin, lycopene, lutein, zeaxanthin and crocetin, and
10 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one emulsifying protective colloid chosen from the group consisting of modified (food) starches, ascorbyl palmitate, pectin, alginate, carrageenan, furcellaran, dextrin derivatives, celluloses and cellulose derivatives (e.g. cellulose acetate, methyl cellulose, hydroxypropyl methyl cellulose), lignosulfonate, polysaccharide gums (such as gum acacia (= gum arabic), flaxseed gum, ghatti gum, tamarind gum and arabinogalactan), gelatine (bovine, fish, pork, poultry), plant proteins (such as are for example peas, soybeans, castor beans, cotton, potatoes, sweet potatoes, manioc, rapeseed, sunflowers, sesame, linseed, safflower, lentils, nuts, wheat, rice, maize, barley, rye, oats, lupin and sorghum), animal proteins including milk or whey proteins, lecithin, polyglycerol ester

	of fatty acids, monoglycerides of fatty acids, diglycerides of fatty acids, sorbitan ester, PG ester and sugar ester (as well as derivatives thereof), and
less than 6 wt.-%,	based on the total weight of the discrete solid extruded particles, of water, and
1 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one auxiliary agent, wherein the auxiliary agent is chosen from the group consisting of antioxidants (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural)), butylated hydroxytoluene (BHT), ascorbyl palmi-tatebutylated hydroxyanisole (BHA), propyl gallate, tert. butyl hydroxyquinoline, ethoxyquin and/or ascorbic acid esters of a fatty acid); plasticisers (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); stabilisers (such as gel-forming agents as xanthan gum, gel-lan gum); humectants (such as glycerine, sorbitol, polyethylene glycol); dyes; fragrances; fillers and buffers,

characterised in that the average particle size of the solid lipophilic active-in-water-dispersion droplets inside the discrete solid extruded particles is less than 300 nm (preferably the average particle size of the solid lipophilic active-in-water-dispersion droplets is between 100 nm and 200 nm) and wherein the particle sizes of the discrete solid extruded particles are lower than 1000 µm (preferably lower than 700 µm, more preferably between 50 - 700 µm).

[0067] Most preferred are discrete solid extruded particles comprising

1 wt.-% to 20 wt.-%,	preferably 1 wt.% - 15 wt.-%, based on the total weight of the discrete solid extruded particles, of β-carotene, and
10 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one modified (food) starch, and
less than 6 wt.-%,	based on the total weight of the discrete solid extruded particles, of water, and
1 wt.-% to 80 wt.-%,	based on the total weight of the discrete solid extruded particles, of at least one auxiliary agent, wherein the auxiliary agent is chosen from the group consisting of antioxidants (such as ascorbic acid or salts thereof, tocopherol (synthetic or natural)), butylated hydroxytoluene (BHT), ascorbyl palmi-tatebutylated hydroxyanisole (BHA), propyl gallate, tert. butyl hydroxyquinoline, ethoxyquin and/or ascorbic acid esters of a fatty acid); plasticisers (such as fructose, glucose, glycerol, mannitol, invert sugar syrup, sorbitol, sucrose, xylitol, propylene glycol, ester of citric acid, lactitol, erythritol and maltitol); stabilisers (such as gel-forming agents as xanthan gum, gel-lan gum); humectants (such as glycerine, sorbitol, polyethylene glycol); dyes; fragrances; fillers and buffers,

characterised in that the average particle size of the solid lipophilic active-in-water-dispersion droplets inside the discrete solid extruded particles is less than 300 nm (preferably the average

particle size of the solid lipophilic active-in-water-dispersion droplets is between 100 nm and 200 nm) and wherein the particle sizes of the discrete solid extruded particles are lower than 1000 μm (preferably lower than 700 μm , more preferably between 50 - 700 μm).

[0068] The discrete solid extruded particles as obtained by the process as described above can be used in many fields of applications. Preferably the discrete solid extruded particles as disclosed and described above are used in food, feed, pharmaceutical and personal care products.

[0069] Therefore a further embodiment of the present invention relates to the use of the discrete solid extruded particles as disclosed and described above in food, feed, pharmaceutical and/or personal care products. It is to be mentioned that dietary supplements are part of our definition of food products.

[0070] A further embodiment of the present invention relates to food, feed, pharmaceutical or personal care products comprising discrete solid extruded particles as disclosed and described above.

[0071] The so obtained products do have good storage stabilities.

[0072] The following Example serves to illustrate the invention. All percentages and parts (if not otherwise indicated) are related to the weight. The temperature is given (if not otherwise indicated) in degree Celsius.

Example

Example 1: Dispersion of β -carotene in modified food starch

[0073] The extrusion dispersion of β -carotene in 10.5 g modified food starch is conducted on a laboratory-scale conical twin-screw (batch) extruder (DSM Xplore 15 ml micro-compounder). 10.5 g of modified food starch (HICAP 100, National Starch), is mixed with 0.75 g of β -carotene (DSM Nutritional Products) and 3.75 g demineralized water. The extruder is operated at a screw speed of 120 rpm and a barrel temperature of 200 °C. The feed hopper and extruder are purged with nitrogen. The mixture is placed in the feed hopper, allowed to pass once through the extruder and exit through a 1 mm die.

[0074] The obtained extrudate strand is partly soluble in water resulting in an orange, cloudy solution stable over 12 hours. This solution is filtered either with a folded filter paper (grade 597 ½: 5 - 7 μm) or a syringe driven filter unit (0.22 μm). Filtration with the larger pores resulted in a turbid, light-yellow solution, while the solution from the fine filter was clear. The hydrodynamic droplet size in these solutions is measured by dynamic light scattering (Malvern

Zetasizer). The average droplet size (Z-Average) in the clear solution is 184 nm, while the turbid solution also contains some larger droplets/particles resulting in a Z-Average of 625 nm. The extrudate strand containing the dispersed β -carotene is let to cool down to room temperature. Subsequently the strands are cut into discrete, solid particles with a pelletizer (Thermo Fisher Scientific) and finally dried in a laboratory-scale fluid bed drier (Retsch TG 200) to obtain a final water content of 6 wt%.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- [US20040201116A \[0009\]](#)
- [WO2006066389A \[0009\]](#)

Patentkrav

1. Fremgangsmåde til fremstilling af adskilte faste ekstruderede partikler, som har en partikelstørrelse på mindre end 1000 μm , fortrinsvis mindre end 700 μm , mere fortrinsvis mellem 50 og 700 μm og omfatter dispersionsdråber, hvor der i et første trin dannes et ekstrudat ved ekstrusion, og ekstrudatet efter ekstrusionen yderligere formes til adskilte faste ekstruderede partikler, og hvor der udføres en dispersionsproces i ekstruderen, og hvor dispersionen omfatter mindst ét carotenoid og mindst ét emulgerende beskyttende kolloid og vand, og hvor carotenoidet er β -caroten, og hvor β -caroten tilsættes til fremgangsmåden som et fast pulver blandet med mindst én modificeret (fødevare-) stivelse.
2. Fremgangsmåde ifølge krav 1, hvor ekstrudatet yderligere formes til adskilte faste partikler ved hjælp af skæring og tørring.
3. Fremgangsmåde ifølge krav 2, hvor tørringen kan udføres før skæring, under skæring eller efter skæring eller en hvilken som helst kombination (sekvens) deraf.
4. Fremgangsmåde ifølge krav 1, hvor ekstrudatet yderligere formes til adskilte faste ekstruderede partikler ved hjælp af en sfæroniseringsproces.
5. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor der anvendes 0,5 vægt-% til 50 vægt-%, fortrinsvis 1 vægt-% til 45 vægt-% baseret på den samlede vægt af dispersionen af mindst ét carotenoid.
6. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor der anvendes 5 vægt-% til 80 vægt-%, fortrinsvis 8 vægt-% til 80 vægt-%, mere fortrinsvis 10 vægt-% til 80 vægt-% baseret på den samlede vægt af dispersionen af mindst ét emulgerende beskyttende kolloid.

7. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor der anvendes 1 vægt-% til 90 vægt-% vand baseret på den samlede vægt af dispersionen.
- 5
8. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav 1 til 7, hvor der anvendes 1 vægt-% til 80 vægt-% vand baseret på den samlede vægt af dispersionen.
- 10
9. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor der anvendes 1 vægt-% til 85 vægt-%, fortrinsvis 1 vægt-% til 80 vægt-% baseret på den samlede vægt af dispersionen af mindst ét hjælpestof.
- 15
10. Fremgangsmåde ifølge krav 9, hvor hjælpestoffet er valgt fra gruppen, der består af antioxidanter (såsom ascorbinsyre eller salte deraf, tocopherol (syntetisk eller naturlig); butyleret hydroxytoluen (BHT); butyleret hydroxyanisol (BHA); ascorbylpalmitat; propylgallat; tert-butylhydroxyquinolin, ethoxyquin og/eller ascorbinsyreestere af en fedtsyre); plastificeringsmidler (såsom fructose, glucose, glycerol, mannitol, invertsukkersirup, sorbitol, saccharose, xylitol, propylenglycol, ester af citronsyre, lactitol, erythritol og maltitol); stabilisatorer (såsom geldannende midler som xanthangummi, gellangummi); fugtighedsbevarende midler (såsom glycerin, sorbitol, polyethylenglycol); farvestoffer; duftstoffer; fyldstoffer og buffere.
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11. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor temperaturen inde i ekstruderen er mellem 20 °C og 220 °C.
- 30
12. Fremgangsmåde ifølge et hvilket som helst af ovennævnte krav, hvor den samlede opholdstid i ekstruderen for bestanddelene er mellem 1 og 400 sekunder.
- 35
13. Adskilte faste ekstruderede partikler, der kan opnås ved hjælp af fremgangsmåden ifølge et hvilket som helst af

ovenstående krav.

14. Partikler ifølge krav 13, som omfatter mindre end 6 vægt-% vand baseret på den samlede vægt af de adskilte faste ekstruderede partikler.

15. Partikler ifølge et hvilket som helst af kravene 13 til 14, som omfatter 1 vægt-% til 80 vægt-% baseret på den samlede vægt af de adskilte faste ekstruderede partikler af mindst ét hjælpestof valgt fra gruppen, der består af antioxidanter (såsom ascorbinsyre eller salte deraf, tocopherol (syntetisk eller naturlig); butyleret hydroxytoluen (BHT); butyleret hydroxyanisol (BHA); ascorbylpalmitat; propylgallat; tert-butylhydroxyquinolin, ethoxyquin og/eller ascorbinsyreestere af en fedtsyre); plastificeringsmidler (såsom fructose, glucose, glycerol, mannitol, invertsukkersirup, sorbitol, saccharose, xylitol, propylenglycol, ester af citronsyre, lactitol, erythritol og maltitol); stabilisatorer (såsom geldannende midler som xanthangummi, gellangummi); fugtighedsbevarende midler (såsom glycerin, sorbitol, polyethylenglycol); farvestoffer; duftstoffer; fyldstoffer og buffere.

16. Anvendelse af partikler ifølge et hvilket som helst af kravene 13 til 15 i en fødevare, et foder, et farmaceutisk produkt eller et personligt plejeprodukt.

17. Fødevare, foder, farmaceutisk produkt eller personligt plejeprodukt, der omfatter partikler ifølge et hvilket som helst af kravene 13 til 15.