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(54) Title: RUMEN PROTECTED PRODUCTS

(57) Abstract: The present invention relates a to a solid dispersion for feeding a ruminant comprising or consisting of i) from 40 wt.-% to 60 wt.-% of a biologically active ingredient, based on the total weight of the solid dispersion, ii) from 60 wt.-% to 40 wt.-% of a carrier, wherein the carrier comprises a mixture comprising from 35 wt.-% to less than 60 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.- % of cellulose, each based on the total weight of the solid dispersion.

Rumen protected products

The present invention is on the field of animal nutrition and relates to ruminant nutrition. Specifically, the present invention relates to rumen protected products for feeding ruminants in the form of a solid dispersion, a process for their production and mixtures containing the solid dispersion and/or the products obtained by said process.

Ruminant animals are mammals of the suborder *Ruminantia* including the well-known cattle, sheep, and goats. They have a stomach divided into four morphologically distinct compartments: the rumen, the reticulum, the omasum, and the abomasum. The rumen and the reticulum are derived from the terminal portion of the esophagus, and the omasum and abomasum are considered to be a genuine stomach. Bacteria present in the rumen enable ruminants to digest cellulosic materials such as grass. Conventional digestion occurs in the abomasum, sometimes called the true stomach.

The rumen, which is essentially a continuous fermenter, supports a variety of microorganisms, which attack and digest much of the ingested feedstuffs consumed by a ruminant as part of their normal life cycle. Ingested protein material is broken down in the rumen to soluble peptides and amino acids that are used as nutrients by the microorganisms. A stream of ingesta, rich in microbial cells, passes out of the rumen into the omasum. The function of the omasum is to separate liquids and solids. Much of the liquid reenters the rumen while the remainder of the material enters the abomasum. Digestion and absorption then proceed in the abomasum in a manner similar to that found in monogastrics. Enzymes secreted into the lumen of the abomasum digest much of the material, including the microbial cells. The digested microbial cells provide protein and amino acids to the ruminant.

The microbial action of the rumen has the great advantage of being able to convert many feed components, which have no direct nutritive value for the host into products, which can be assimilated and utilized by the host. For example, cellulose may be converted to a mixture of volatile fatty acids, which can serve as a source of energy to the host.

However, this microbial action also presents certain disadvantages. For instance, soluble proteins of high nutritive value may be broken down and digested in the rumen and in part resynthesized into microbial protein of lower nutritive value. Amino acids are also chemically changed by the rumen microorganisms, which convert amino acids to carbon dioxide, volatile fatty acids, and ammonia.

All proteins present in animals are constituted by combinations of more than 20 different amino acids. Among these, ten essential amino acids are not adequately synthesized in the animal body, and the animal must take them in. These ten amino acids are also referred to as essential or growth limiting amino acids. When essential amino acids are lacking in the ruminant diet the ruminant's health, milk production, etc., are all negatively affected.

It is therefore common practice in ruminant production to supply biologically active ingredients in the daily diet of the animals in order to improve their conditions of health and their productive performance. Active ingredients of interest include amino acids, vitamins, enzymes, nutrients such as protein and carbohydrates, probiotic microorganisms, prebiotic foods, mineral salts, choline, guanidino acetic acid, etc. Some of these ingredients are already present in foods used for feeding animals. Sometimes the amount of essential active ingredients present in the diet may be insufficient or inadequate to cope with states of deficiency or situations of high productivity. Therefore, it is desirable to carefully formulate or supplement the daily diet of ruminant animals in order to address these concerns.

However, when physiologically active ingredients such as amino acids and proteins are orally fed, a substantial part of the ingredient, e.g., proteins and amino acids, are decomposed by microorganisms in the rumen. This makes it difficult or even impossible for the animal to effectively utilize all or relevant amounts of the administered proteins and amino acids contained in the feed, etc. Accordingly, essential amino acids are destroyed or converted and thus rendered unavailable for the growth of animals and animal production in general. However, animal production is limited by the supply of individual amino acids that should escape or bypass the rumen intact and reach the lower gastrointestinal tract of the animal, where they can be absorbed and become available for animal production. Accordingly, it is important to pass the biologically active ingredients through the rumen without decomposition by microorganisms to allow the biologically active ingredients to be effectively digested and absorbed in the abomasum and subsequent digestive tract.

Numerous products were designed for the delivery and protection of biologically active ingredient. For example, WO 2006/32958 A2 discloses a composition in pellets with controlled release of physiologically active substances comprising a comprising a one or more physiologically active substances; a matrix comprising a carnauba wax and/or a microcrystalline wax, a first layer of a coating comprising a first hydrophobic substance, and a second layer of a coating comprising a second hydrophobic substance.

WO 2014/011857 A1 discloses the preparation of coated particles, wherein particles of the calcium salt of HMTBa (2-hydroxy-4-methylthiobutanoic acid) are coated with a first layer of a polymer such as ethyl cellulose (EC), followed by a second layer comprising stearic acids and hydrogenated soybean oil, or the HMTBa oligomer, ethyl cellulose and/or $CaCO_3$.

EP 678246 A2 discloses a granular additive composition for ruminant feed, which comprises a core comprising a biologically active substance and a coating composition coated thereon, said coating composition comprising 65 to 90 % by weight of (A) at least one hydrophobic protecting substance selected from the group consisting of hardened animal and plant oil and fat, an animal and plant fat, and a fatty acid ester, 2 to 10 % by weight of (B) a surface active agent compatible with said hydrophobic protecting substance (A) and 8 to 30 % by weight of (C) talc powder.

However, the disclosed protective materials, in particular fats or waxes, mostly have brittle material properties. This has negative effects on the particles coated with said protective materials upon typical handling or storage of the particles. Specifically, the brittleness reduces the mechanical stability. Due to the action of pressure and shear forces on the particles, they can either break or material can be removed at corners and edges. In any case this leads to a significantly increased release rate of the biologically active substance in the rumen, which significantly reduces the protection of the biologically active substance against degradation. The storage conditions, in particular temperature and air humidity, also negatively affect the protection of the biologically active substance against degradation since they lead to a softening of the protection material or to a separation of the individual components in the coating or protection composition.

On the other hand, the protective materials must also provide for a sufficient mechanical stability so that the product can be further processed easily without deforming, crushing, or destructing the product.

WO 2010/143066 A1 discloses an edible oleogel comprising an oil, an ethylcellulose and a surfactant, prepared by combining ethylcellulose with an edible oil and a surfactant, and heating the mixture to a temperature above the glass transition temperature of the ethylcellulose. Once the ethylcellulose has fully dissolved and the solution is clear, it is allowed to cool and set as a gel. In this way, liquid edible oils are transformed into anhydrous semisolid gels. The resulting oleogel is homogeneous, elastic, substantially anhydrous, and has a gelation temperature below 100 °C. In the contest of the present invention, Example 2 of WO 2010/143066 A1 was reproduced (see comparative Example below). The reproduction of this example gave a product that did not harden enough for any type of further processing, such as mixing, cutting, or chopping into smaller pieces. Rather, the product hardly solidified and remained very soft, so that it could be crushed without any effort and without using any power. Accordingly, oleogels and the products obtained according to the technical teaching of WO 2010/143066 A1, and in particular of Example 2 of WO 2010/143066 A1, do not have the mechanical stability which is desired and required for use in livestock production.

Accordingly, there was still a need for an improved product, comprising biologically active ingredient, for feeding a ruminant, which does not suffer from the disadvantages mentioned above.

It was found that this problem is solved by forming a solid dispersion of a biologically active ingredient with a carrier, wherein the carrier comprises a hydrogenated fat, which provides for rumen protection, and cellulose, which provides for storage stability.

One object of the present invention is therefore a solid dispersion for feeding a ruminant comprising or consisting of

i) from 40 wt.-% to 60 wt.-% of a biologically active ingredient, based on the total weight of the solid dispersion,

ii) from 60 wt.-% to 40 wt.-% of a carrier, wherein the carrier comprises a mixture comprising from 35 wt.-% to less than 60 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.-% of cellulose, each based on the total weight of the solid dispersion.

Solid dispersions have achieved significant interest in the field of pharmaceutics or drug formulation as an effective means of enhancing the dissolution rate and thus the bioavailability of a range of weakly water-soluble drugs. Hence, solid dispersions of weakly water-soluble drugs with water-soluble carriers have lowered these problems and improved dissolution. In the field of pharmaceutics solid dispersions are known as a solubilization technology emphasizing mainly on drug-polymer two-component systems in which drug dispersion and its stabilization is the key to formulation development. In pharmaceutics, the term solid dispersion is defined as a group of solid products consisting of a hydrophobic drug dispersed in at least one hydrophilic carrier, resulting in increased surface area and, enhanced drug solubility and dissolution rate.

In the context of the present invention, the term solid dispersion is used to denote a group of solid products. In these products the biologically active ingredient, which is typically readily water-soluble, is formulated with a carrier to form a solid dispersion, which provides rumen protection to said biologically active ingredient. Specifically, the thus formed solid dispersion aims at achieving a high protection of the biologically active ingredient in the rumen, in particular under the conditions in the rumen, and at a high bioavailability of the biologically active ingredient after the rumen, in particular under the conditions in the small intestine.

By comparison, typical rumen protection compositions are coated products comprising a core with the active ingredient and upon the core a layer with the coating material. Thus, in contrast to a coated product, the solid dispersion according to the present invention does not have a core and it does not have a layer or shell. Consequently, the solid dispersion according to the present invention also has no concentration gradient for the active ingredient over the cross section of the product as in a traditional core-shell product, where you do not have any active ingredient in the shell but only in the core. Rather, the active ingredient is homogeneously and evenly distributed over the whole solid dispersion. At the same the biologically active ingredient is sufficiently dispersed in the carrier to provide the said active ingredient with the desired rumen protection.

In the context of the present invention the term carrier is used for the mixture of components which allow for the formulation of a solid dispersion of the biologically active ingredient. According to the present invention the carrier comprises a mixture comprising from 35 wt.-% to less than 60 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.-% of cellulose, each based on the total weight of the solid dispersion.

In an embodiment of the solid dispersion according to the present invention the biologically active ingredient is homogeneously distributed over the whole solid dispersion.

In context of the present invention the term biologically active ingredient is used to denote any compound which has a functional or nutritive activity to a biological system, such as the organism of an animal, in particular of a ruminant, e.g., cattle, sheep or goat. Typically, a biologically active ingredient exhibits low stability and thus a reduced or even no bio-effectiveness when being exposed to unfavorable conditions, for example moisture, elevated temperature, oxygen and acidic and/or basic pH. When the biologically active ingredient is exposed to such conditions, it can for example decompose, dissociate, deactivate, and/or lose availability. The term biologically active ingredient therefore refers to, for example, i) amino acids, such as lysine, methionine, tryptophan, arginine, histidine, isoleucine, leucine, phenylalanine, valine, and threonine, derivatives of amino acids, such as *N*-acylamino acids, e.g., *N*-acylmethionine, and *N*-guanylamino acids, e.g., *N*-guanylglycine also known as guinidinoacetic acid, and/or salts of amino acids, such as lysine sulfate, lysine hydrochloride, and the salts of lysine with polyunsaturated fatty acids, and/or of their derivatives, such as 2-hydroxy-4-(methylthio)butyric acid calcium salt, also known as the calcium salt of methionine hydroxy analogue (calcium MHA), ii) proteins, such as casein, corn proteins, and potato proteins, iii) peptides, such as oligopolypeptides, e.g., methionylmethionine (met-met) and/or polypeptides, iv) carbohydrates, such as starch, cane sugar, and glucose, v) vitamins, derivatives of vitamins, vitamin A, vitamin A acetate, vitamin A palmitate, vitamin B, thiamine, thiamine hydrochloride, riboflavin, inositol, nicotinic acid, nicotinic acid amide, niacin, calcium pantothenate, choline pantothenate, ascorbic acid, hydrochloride, choline chloride, cyanocobalamine, biotin, folic acid, *p*-aminobenzoic acid, vitamin B12, vitamin D, vitamin D2, vitamin D3, vitamin E, vitamin K, and the like, vi) probiotic microorganisms, vii) prebiotic foods, viii) choline, choline salts and/or derivatives thereof, ix) polyunsaturated fatty acids (PUFAs), such as omega-3 fatty acids, e.g., alpha-linolenic acid (ALA), eicosapentanoic acid (EPA), and docosahexanoic acid (DHA) and salts and/or derivatives thereof, and x) a compound of medical use, such as methylsulfonylmethane.

Preferably, the biologically active ingredient is readily water-soluble.

In one embodiment of the solid dispersion according to the present invention the biologically active ingredient is selected from the list consisting of i) amino acids, derivatives of amino acids, and/or salts of amino acids and/or of their derivatives, ii) proteins, iii) peptides, iv) carbohydrates, v) vitamins, and derivatives of vitamins, vi) probiotic microorganisms, vii) prebiotic feeds, viii) choline, choline salts and/or derivatives thereof, ix) polyunsaturated fats (PUFAs), derivatives thereof, and/or salts thereof, and x) pharmaceuticals.

In principle, the solid dispersion according to the present invention is not subject to any limitation regarding the number of biologically active ingredients comprised in it. Therefore, the solid dispersion according to the present invention can comprise one or more biologically active ingredients.

In context of the present invention the term fat is used to denote the esters formed of fatty acids with the alcohol glycerol, which are also known as glycerides. Typically, fats are triglycerides, i.e., esters formed of three fatty acids with glycerol, wherein all three alcohol groups of glycerol are esterified. In the context of the present invention the term fat and in particular the terms saturated fat, hydrogenated fat, saturated vegetable oil, and hydrogenated vegetable oil also comprises monoglycerides and/or diglycerides, where only one or two of the alcohol groups of glycerol are esterified.

In context of the present invention the term saturated fat, e.g., hydrogenated fat, is used to denote a fat in which the fatty acid chains have predominantly single bonds. The term saturated fat also includes hydrogenated fats, in which all or most of the double bonds which were or may have previously been present in the fat were reacted with hydrogen to form single bonds. They are called hydrogenated, because the second bond is broken up and each half of the bond is attached to (saturated with) a hydrogen atom. Hydrogenated vegetable oil typically contains triglycerides of a mixture of saturated fatty acids with different chain lengths. In addition, the hydrogenated vegetable oil can also contain monoglycerides or diglycerides. Further, the term saturated fat also includes those saturated fats which are obtained by fractionated distillation of a mixture of different fats, e.g., mixture of unsaturated and saturated fats.

Any indications of weight or weight percent also indicate that (slight) deviations from the mentioned or encompassed values, which however, still lead to essentially the same effect as the present invention, are also encompassed by the present invention. This is particularly relevant with respect to saturated fats, and in particular hydrogenated vegetable oils, because the fat from which the saturated fat, and in particular the hydrogenated vegetable oil, is obtained is a natural product of varying quality and composition, irrespective of whether it is a natural, synthetic, or fractionated (hydrogenated) vegetable oil.

In principle, the present invention is not subject to any limitations regarding the number of saturated fats comprised by the carrier according to the present invention. Therefore, said carrier can comprise one or more saturated fats.

The specific choice of the saturated fat, e.g., hydrogenated fat, may also make a valuable contribution in order to achieve the desired effect of high amounts of metabolizable biologically active ingredient (BAI). It was found that the selective choice of a suitable saturated fat, e.g., hydrogenated fat, leads to a solid dispersion with a flawless carrier, which is believed to contribute to achieving a high rumen protected BAI fraction. It is further believed that the use of a saturated fat, e.g., hydrogenated fat, with a melting point as wide as possible, or in other words a melting range as wide as possible, in particular allows the production of a BAI comprising product which gives a high rumen protected BAI fraction. A further advantage of the carrier as taught herein is that it adds nutritional value to the solid dispersion according to the present invention.

Vegetable oils contain a mixture of various fats. For example, vegetable oils contain a variety of glycerides of different fatty acids, i.e., fatty acids with different chain lengths. For example, palm oil contains about 41 to about 46% of glycerides of palmitic acid, about 37 to about 42% of glycerides of oleic acid, about 8 to about 10% of glycerides of linoleic acid, about 4 to about 7% of glycerides of stearic acid, and about 2% or less of glycerides of other fatty acids, and soybean oil contains about 17 to about 31 % of glycerides of oleic acid, about 48 to about 59% of glycerides of linoleic acid, about 2 to about 11 % of glycerides of linolenic acid, and glycerides of other fatty acids, such as about 2 to about 11 % of glycerides of palmitic acid and/or 2 to 7% of glycerides of stearic acid. Possible saturated fats or oils in the context of the present invention are for example hydrogenated plant oils, such as palm oil, soya oil, rapeseed oil, sunflower oil or castor oil. Accordingly, the present invention is not subject to any limitations regarding the use of a specific hydrogenated fat and in particularly, with respect to the use of a specific hydrogenated fat. However, it was found that the use of a hydrogenated vegetable oil provides the solid dispersions according to the present invention with a high rumen protected fraction of the biologically active ingredient. Preferably, said hydrogenated vegetable oil is completely hydrogenated.

In one embodiment of the solid dispersion according to the present invention the saturated fat comprises or consists of a hydrogenated fat, e.g., a hydrogenated vegetable oil.

In principle, the solid dispersion according to the present invention is also not subject to any limitations regarding the number of hydrogenated vegetable oils. Therefore, the hydrogenated fat can also be a mixture of two or more hydrogenated vegetable oils, for example two, three or even more hydrogenated vegetable oils. Suitable hydrogenated vegetable oils comprise hydrogenated palm oil, hydrogenated rapeseed oil and hydrogenated soybean oil or mixtures of any of these.

It was further found that solid dispersions according to the present invention, wherein the saturated fat is a hydrogenated vegetable oil, preferably a hydrogenated palm oil, hydrogenated soybean oil, and/or hydrogenated rapeseed oil, allow the release of a high fraction of biologically active ingredient in the small intestine and thus allow to provide the ruminant with a high amount of metabolizable biologically active ingredient.

In an embodiment of the solid dispersion according to the present invention the hydrogenated fat comprises or consists of a hydrogenated vegetable oil.

In a preferred embodiment of the solid dispersion according to the present invention the hydrogenated fat comprises or consists of hydrogenated palm oil, hydrogenated soybean oil and/or hydrogenated rapeseed oil.

In principle, the solid dispersion according to the present invention is not subject to any limitation regarding a specific type of cellulose. Therefore, any type of cellulose can be used in the solid dispersion according to the present invention. For example, the cellulose can be cellulose as such

or a cellulose derivative, such as, a carboxymethyl cellulose (CMC), an ethyl cellulose (EC), a methyl cellulose (MC), or a hydroxypropyl methylcellulose (HPMC). For example, the cellulose can be any cellulose powder, i.e., powdery cellulose, any cellulose fiber, i.e., fibrous cellulose, any type of powdered cellulose or a mixture of any of these. When the cellulose is powdery cellulose, it is preferred that it is microcrystalline cellulose. When the cellulose is fibrous cellulose, it is preferred that it has an average fiber length of ca. 200 to ca. 300 µm.

In another embodiment of the solid dispersion according to the present invention the cellulose is cellulose powder and/or cellulose fiber.

Preferably, the solid dispersion according to the present invention comprises from more than 0 to 2 wt.-% of cellulose, in particular, cellulose powder and/or cellulose fiber.

It is further preferred that the solid dispersion according to the present invention comprises from 0.25 wt.-% to 2 wt.-% of cellulose, in particular, of cellulose powder and/or cellulose fiber.

The additional presence of a fatty acid in the carrier provides the solid dispersions according to the present invention with an improved release rate in the intestinal tract of the ruminants. Specifically, this effect is achieved when the solid dispersion comprises from more than 0 to 10 wt.-% of a fatty acid, based on the total weight of the solid dispersion. In principle, the carrier of the solid dispersion according to the present invention is not subject to any limitations regarding the number of fatty acids. Therefore, said carrier can comprise one or more fatty acids. In context of the present invention the term fatty acid is used as known to the person skilled in the art and denotes a carboxylic acid with a long C_4 to C_{28} aliphatic chain, which is either saturated or unsaturated. Said fatty acid may be branched or unbranched, but preferably it is unbranched.

In an embodiment of the solid dispersion according to the present invention, the carrier further comprises from more than 0 to 10 wt.-% of a fatty acid, based on the total weight of the solid dispersion.

Further, the carrier is also not subject to any limitations regarding the chain lengths of the one or more fatty acids. However, the most prevalent fatty acids in hydrogenated fats, preferably hydrogenated vegetable oils, such as palm oil, hydrogenated soybean oil, and/or rapeseed oil, are C_{14} to C_{22} carboxylic acids. It was found that a fatty acid with a similar or even identical chain length as the one or those ones comprised in the hydrogenated vegetable oil improves the quality of the carrier, both in terms of a protective material against degradation in the rumen and in terms of the release rate in the intestinal tract of the rumen. Without wishing to be bound to a specific theory, it is believed that this may be due to the good miscibility of fatty acids and hydrogenated vegetable oils with similar or even identical chain lengths. Thus, they give a homogeneous mixture which is believed to contribute to a homogenous carrier composition without any imperfections.

In a preferred embodiment of the solid dispersion according to the present invention, the fatty acid comprises or consists of a C_{14} to C_{22} carboxylic acid.

Preferred hydrogenated vegetable oils are palm oil and/or soybean oil. The most prevalent fatty acids in these hydrogenated vegetable oils are C_{16} to C_{22} carboxylic acid. It is therefore preferred that the fatty acid comprises or consists of a C_{16} to C_{22} carboxylic acid. Examples of suitable C_{16} to C_{22} carboxylic acids are palmitic aid, margaric acid, stearic acid, nonadecylic acid, arachidic acid, and behenic acid.

According to the present invention the carrier comprises a hydrogenated fat, preferably a hydrogenated vegetable oil. In order to further improve the miscibility of said hydrogenated fat with the fatty acid, it is therefore preferred that the fatty acid is also hydrogenated.

In a further embodiment of the solid dispersion according to the present invention, the fatty acid comprises of consists of a saturated fatty acid.

Preferably, the fatty acid comprises or consists of an optionally substituted palmitic acid, oleic acid, and/or stearic acid.

It was also found that the additional presence of an emulsifier in the carrier of the solid dispersion according to the present invention leads to an increase in digestibility of the biologically active ingredient. Specifically, it was found that the presence of from more than 0 to 5 wt.-%, preferably from 0.5 to 2 wt.-%, of an emulsifier, optimizes the digestibility of the biologically active ingredient up to 100%. In the context of the present invention the term emulsifier or emulsifying agent is used synonym to emulgent and denotes a substance that stabilizes an emulsion by increasing its kinetic stability. Emulsifiers are part of a broader group of compounds known as surfactants, or “surface active agents”. Surfactants (emulsifiers) are compounds that are typically amphiphilic, meaning they have a polar or hydrophilic, i.e., water-soluble, part and a non-polar, i.e., hydrophobic or lipophilic, part. Suitable emulsifiers may be egg yolk, mustard, lecithin, e.g., soy lecithin, sodium phosphates, mono- and diglycerides, a lactate, sodium stearoyl lactylate, diacetyl tartaric esters of mono- and diglycerides, and proteins. Preferably, the emulsifier is a lecithin, a lactate and/or a citrate.

In one embodiment of the solid dispersion according to the invention the carrier further comprises from more than 0 to 5 wt.-% of an emulsifier, based on the total weight of the solid dispersion.

Preferably, the carrier further comprises from 0.5 wt.-% to 2 wt.-% of an emulsifier, based on the total weight of the solid dispersion.

In the context of the present invention the term biologically active ingredient is not subject to any limitations. Rather, this term is used to denote any compound which provides a functional or nutritive benefit to an animal, in particular to a ruminant, e.g., a cattle, sheep, or goat. Typically, a biologically

active ingredient exhibits low stability and thus has a reduced or even no bio-effectiveness when being exposed to unfavorable conditions, for example, moisture, elevated temperatures, oxygen, and an acidic and/or basic milieu. When being exposed to such conditions, the biologically active ingredient can decompose, dissociate, deactivate and/or lose availability. Preferred biologically active ingredients are i) amino acids, such as lysine, methionine, tryptophan, arginine, histidine, isoleucine, leucine, phenylalanine, valine, and threonine, derivatives of amino acids, such as *N*-acylamino acids, e.g., *N*-acylmethionine, and *N*-guanylamino acids, e.g., *N*-guanylglycine, also known as guanidinoacetic acid, and/or salts of amino acids, such as lysine sulfate, lysine hydrochloride, and the salts of lysine with polyunsaturated fatty acids, and/or of their derivatives, such as 2-hydrox-4-(methylthio)butyric acid calcium salt, also known as the calcium salt of methionine hydroxy analogue (calcium MHA), ii) proteins, such as casein, corn proteins, and potato proteins, iii) peptides, such as oligopeptides, e.g., methionylmethionine (met-met), and/or polypeptides, iv) carbohydrates, such as starch, cane sugar, and glucose, v) vitamins, derivatives of vitamins, vitamin A, vitamin A acetate, vitamin A palmitate, vitamin B, thiamine, thiamine hydrochloride, riboflavin, inositol, nicotinic acid, nicotinic acid amide, niacin, calcium pantothenate, choline pantothenate, ascorbic acid hydrochloride, choline chloride, cyanocobalamine, biotin, folic acid, *p*-aminobenzoic acid, vitamin B12, vitamin D, vitamin D2, vitamin D3, vitamin E, vitamin K, and the like, vi) probiotic microorganisms, vii) prebiotic feeds, viii) choline, choline salts, and/or derivatives thereof, ix) polyunsaturated fatty acids (PUFAs), such as omega-3 fatty acids, e.g., alpha-linolenic acid (ALA), eicophentanoic acid (EPA), and docosahexanoic acid (DHA), and salts and/or derivatives thereof, and x) pharmaceuticals, such as methylsulfonylmethane.

In one embodiment of the solid dispersion according to the present invention, the biologically active ingredient is selected from the list consisting of i) amino acids, derivatives of amino acids, and/or salts of amino acids and/or of their derivatives, ii) proteins, iii) peptides, iv) carbohydrates, v) vitamins, and derivatives of vitamins, vi) probiotic microorganisms, vii) prebiotic feeds, viii) choline, choline salts, and/or derivatives thereof, ix) polyunsaturated fatty acids (PUFAs), and salts and/or derivatives thereof, and x) pharmaceuticals.

It may be advantageous to further enhance the nutritional value and/or therapeutic value of the solid dispersion according to the present invention by adding a further feed ingredient, e.g., nutritional ingredients, veterinary, or medicinal agents etc., or other ingredients to the solid dispersion as taught herein.

For example, the one or more ingredients to be added can be selected from grain products, plant products, animal products, proteins (e.g., protein ingredients obtained from sources such as dried blood or meat meal, bone meal, cottonseed meal, soybean meal, rapeseed meal, sunflower meal, canola meal, safflower meal, dehydrated alfalfa, corn gluten meal, soybean protein concentrate, potato protein, dried and sterilized animal and poultry manure, fish meal, fish and poultry protein isolates, crab protein concentrate, hydrolyzed protein feather meal, poultry by-product meal, liquid or powdered egg, milk whey egg albumen, casein, fish solubles, cell cream, brewer's residues, and

the like), mineral salts, sugars and complex carbohydrates (e.g., water-soluble and water-insoluble monosaccharides, disaccharides, oligosaccharides, and polysaccharides), veterinary compounds (e.g., promazine hydrochloride, chloromedoniate acetate, chlorotetracycline, sulfamethazine, monesin, poloxalene, oxytetracycline, bovatec®, and the like), antioxidants (e.g., butylated hydroxyanisole, butylated hydroxytoluene, tertiary butylhydroquinone, tocopherols, propyl gallate, and ethoxyquin), trace elements ingredients (e.g., compounds of cobalt, copper, manganese, selenium, calcium, magnesium, sodium, potassium, and the like), and other compounds or ingredients.

When the solid dispersion according to the present invention has a large particle diameter, it is easier for ruminants to chew the product. In this case, however, the biologically active ingredient would get lost in the rumen and thus, it would not be available at all for adsorption in the intestinal tract of the ruminant. Therefore, the solid dispersion according to the present invention should have a particle diameter of not more than 5 mm, in order to avoid getting chewed. Preferably, the solid dispersion according to the present invention has a particle diameter of from 1 to 5 mm, or from 2 to 4 mm, each with the endpoints being included.

In principle, the solid dispersion according to the present invention is not limited to any specific process for its preparation, provided that it gives or provides the product in question with the beneficial properties according to the present invention. In the simplest way, the solid dispersion according to the present invention is produced by providing a liquefied mixture comprising the components of the product to be prepared, i.e., comprising the biologically active ingredient to be dispersed in the carrier and the components of the matrix, followed by portioning the liquefied mixture, and cooling the thus obtained portions or allowing them to cool down to give the solid dispersion.

A further object of the present invention is therefore a process for the production of a solid dispersion according to the present invention, comprising the steps of

a) providing a liquefied mixture comprising from 40 wt.-% to 60 wt.-% of a biologically active ingredient, from less than 60 wt.-% to 35 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.-% of cellulose, each based on the total weight of the solid dispersion to be prepared,
b) portioning the liquefied mixture provided in step a), and
c) cooling the portions obtained in step b) or allowing them to cool down to give the solid dispersion.

In an embodiment the step a) of said process further comprises the steps of

a1) providing a melt of a hydrogenated fat, e.g., a hydrogenated vegetable oil,
a2) adding an emulsifier, e.g., from more than 0 to 5 wt.-% of an emulsifier, based on the total weight of the solid dispersion to be prepared, to the melt of step a) to give a first mixture,

a3) adding a biologically active ingredient to the first mixture of step a2) to give a second mixture, and

a4) adding cellulose powder and/or cellulose fiber to the second mixture of step a3) to give a liquefied mixture.

Depending on the solubility of the biologically active ingredient in question and the size of the cellulose, the resulting liquefied mixture can vary in its appearance. For example, if the biologically active ingredient is an amino acid, it will not give a solution with the cellulose, and then the resulting mixture will be a melt dispersion.

In principle, the provision of the mixture of step a) is not subject to any limitations regarding the sequence of the steps a1) to a4). Therefore, the sequence of steps a1) to a4) may vary in any conceivable way from the sequence mentioned above, provided that the thus obtained solid dispersion has the same beneficial properties as the solid dispersion according to the present invention. For example, the step a2) may be followed directly by step a4), which then would be followed by step a3). In order to provide for the best possible mixing of the components it is preferred that each of the steps a1) to a4) is performed under stirring. It is further preferred that mixing is continued after the completed addition of all components until the thus obtained mixture is clear or at least makes a homogeneous impression. Further, the biologically active ingredient is preferably used in fine-grained form, e.g., having a particle size of not more than 100 µm, in order to provide for the best possible dispersion.

In a further embodiment the step a) of said process further comprises adding a fatty acid, e.g., from more than 0 to 10 wt.-% of a fatty acid, based on the total weight of the solid dispersion to be prepared, to any of the mixtures, e.g., to the mixture of a1), a2), a3), and/or a4). This step may be performed either as a single step or simultaneously with any of the steps a1) to a4). Preferably, the said fatty acid is a saturated fatty acid.

In principle, the step b) of said process is not subject to any limitations regarding the way the portioning is performed, e.g., regarding the type of equipment or device used for portioning, provided that the thus obtained solid dispersion has the same beneficial properties as the solid dispersion according to the present invention. For example, the portioning can be done by pastillation, flaking, granulation, drip casting, prilling, or spraying. Nevertheless, it is preferred that the step b) of said process is performed using one or more nozzles, a perforated sheet, a roller with a series or multitude of nozzles, or a rotating disc with a series or multitude of nozzles.

In alternative to a single use, it is also possible to combine the solid dispersion according to the present invention and/or the solid dispersion obtained by the process according to the present invention into a feed, feed material, or premix for feeding a ruminant. In the context of the present invention the term premix is used synonymous with nutrient premix and denotes a mixture comprising one or more ingredients such as vitamins, trace minerals, pharmaceuticals, feed supplements and

diluents. The use of premixes has the advantage that a farmer who uses his own grain can formulate the diets for the livestock on his own and be assured that the livestock always gets the recommended level of minerals and vitamins.

Preferably, the feed, feed material, feed additive or premix further comprises a vitamin, trace mineral(s), feed supplement diluent(s), and/or pharmaceuticals, probiotics and/or prebiotics.

It was found that administering the solid dispersion according to the present invention, and/or the solid dispersion obtained by the process according to the present invention is suitable to compensate amongst others for a lack of nutrients, e.g., essential amino acids, in a ruminant diet.

Yet a further object of the present invention is therefore a method of supplementing the diet of a ruminant with a biologically active ingredient, comprising the step of providing the ruminant with the solid dispersion according to the present invention, and/or the solid dispersion obtained by the process according to the present invention.

Examples:

I. Comparative Example: Preparation of the product of Example 2 of WO 2010/143066 A1

Example 2 of WO 2010/143066 A1 was repeated.

Ethylcellulose 22cp 9% w/w (from Sigma-Aldrich) and 3% w/w sorbitan monostearate (chip 60, from TCI) in a 30:70 w/w mixture of fully hydrogenated soybean oil (from Fauth) with liquid soybean oil were placed in a 100mL three-neck flask and heated up to 140 °C using an oil bath. It was ensured that a full solubilization of the polymer in oil was achieved. After about 30 minutes, all three components have melted. Upon cooling of the melt, at 90 °C, algae oil (from Veramaris) heated to 90 °C was slowly added under a nitrogen blanket at a ratio of 1:2 (1/3 dilution). The final concentration of the components was 6% ethylcellulose, 2% sorbitan monostearate, 20% fully hydrogenated soybean oil, and 72% algae oil. The result was a brown, clear solution. A sample was taken from the solution with a Pasteur pipette. With the help of the pipette, attempts were made to produce some pastilles. For this purpose, individual drops were carefully placed on the worktop. However, these drops did not harden enough for any type of further processing, such as cutting or chopping into smaller pieces. Rather, the drops hardly solidified, they remained very soft, so that they could be crushed without any effort and without using any power.

The conclusion is that the product of Example 2 of WO 2010/143066 A1 is not a solid product and in particular not a solid dispersion.

II. Preparation of the products 1 to 10 according to the invention

Products 1 to 10 according to the invention, solid dispersions comprising a biologically active ingredient, were prepared according to this general procedure:

The saturated fat (hydrogenated palm oil) was provided in a beaker and pre-heated to 80 °C with a heated magnetic stirrer to cause a melting of the fat. If necessary, the saturated fat was liquefied by heating to 120 °C and it was well mixed with a magnetic stirrer. For products 8 to 10 lecithin was added to the molten or liquefied fat. Subsequently, the fine-grained (< 100 µm) biologically active ingredient, i.e., Lys*HCl, was added in portions and under stirring to the homogeneous melt to give a suspension. Next, cellulose fibers (fiber length of 200 to 300 µm) were added under stirring to the suspension and the thus obtained mixture was further stirred for ca. 30 minutes at 80 °C to achieve to high mixing quality and a good distribution of the cellulose fibers in the mixture. Subsequently, the melt was dripped onto a moving cold sheet by means of a dripping apparatus (Mini Droppo, Fa. Maag Automation) to give pastilles with a diameter of 3 to 5 mm. After cooling to room temperature, the thus obtained pastilles were stored in a closed vessel until further use.

The composition of the thus prepared products 1 to 7 is given in the Table 1. The composition of the thus prepared products 8 to 10 is given in the Table 2.

III. Preparation of the products 11 to 13 according to the invention

Further solid dispersions according to the invention comprising a biologically active ingredient were prepared according to the procedure of Example I above, with the exception that a mixture of the saturated fat (hydrogenated palm oil) and the fatty acid (stearic acid) was provided in a beaker.

The composition of the thus prepared solid dispersions 11 to 13 is given in the Table 3.

IV. Preparation of the products C1 and C2 not according to the invention

The products C1 and C2 not according to the invention were prepared according to Example I with the exception that no cellulose fibers were added.

The composition of the thus prepared products C1 and C2 is given in the Tables 1 and 2.

V. Determination of breaking strength

The products 1 to 7 and 11 to 13 according to the invention and the product C1 not according to the invention were subjected to mechanical strength tests for determining the breaking strength of the products. The breaking strength of the products was determined using a rheometer (Anton Paar, powder rheometer). For this purpose, particles of the products in question were mechanically loaded (only pressure, no shearing force) by means of a disc/disc arrangement, and the resulting breaking force was measured in newton [N].

The results are summarized in the Tables 1 and 3.

VI. In vitro testing of the products 1 to 7 and C1

The products 1 to 7 according to the invention and the product C1 not according to the invention were subjected to an in vitro test to simulate the ruminal digestion, in particular to simulate the release rates of the biologically active ingredient, i.e., Lys*HCl, in the three different compartments rumen, abomasum and small intestine of the ruminal digestive tract according to the in vitro protocol below.

In vitro test protocol:

For this purpose, the tests were performed in a three-step incubation procedure: in the first step the conditions in the rumen were simulated by use of the McDougall's buffer, in the second step the conditions in the abomasum were simulated by use of hydrochloric acid and pepsin, and in the third step the conditions of the small intestine were simulated by use of pancreatin and a suitable buffer to adjust a pH of 8. The in vitro tests were performed according to the following procedure:

For the preparation of the McDougall's buffer the following substances were weighed into a 10 liters bottle:

- $NaHCO_3$	98 g (1.17 mol)
- $Na_2HPO_4 \cdot 2\ H_2O$	46.3 g (0.26 mol)
- NaCl	4.7 g (0.08 mol)
- KCl	5.7 g (0.08 mol)
- $CaCl_2 \cdot 2\ H_2O$	0.4 g (2.7 mmol)
- $MgCl_2 \cdot 6\ H_2O$	0.6 g (3.0 mmol)

250 mL of the McDougall's buffer solution were filled into a 1000 mL Schott flask. 5 grams of the test substance containing 2.5 g of the BAI (50 wt.-%), i.e., any of the products mentioned above were added, and the flasks were shaken at 100 rotations per minute in a lab shaker (Innova 40, New Brunswick Scientific) at 39°C. After 6 hours, the flask content was filtered off carefully, washed with

50 mL of cold water and directly transferred to the second flask containing 250 mL concentrated hydrochloric acid with pH=2 and a small amount of pepsin. After 2 hours incubation time at 39°C, the product was again filtered off carefully, washed with 50 mL of cold water and subsequently transferred to a third flask containing freshly prepared solution containing 14.4 mg tri(hydroxymethyl)aminomethane, 56.2 mg NaCl, 231 mg phosphatidylcholine, 60 mg Triton-X-100, 240 mg Na taurocholate, 300 mg $CaCl_2$ x 2 H_2O and 120 mg pancreatin (≥ 8 USP lipase units/mg). After shaking for 24 hours, the product was filtered off, washed again with cold water and dried at 40°C overnight. The residual product was weighted after each of steps 1 and 3 and the weight loss was considered to be the loss in biologically active substance.

The ruminal release fraction of the biologically active ingredient (BAI) was calculated with the following formula:

5 g of a test substance comprising Lys*HCl were used. This corresponds to an initial amount of 2.5 g of BAI.

Ruminal BAI release fraction [%] = ((initial amount of BAI [g] – residual amount of BAI after the 1st step of the McDougall method [g]) / initial amount of BAI [g])) x 100%.

Example: initial amount of BAI = 2.5 g
residual amount of BAI = 2.1 g

Ruminal release fraction [%] = ((2.5 g – 2.1 g) / (2.5 g)) x 100% = 16%

The rumen protected (RP) fraction of the biologically active ingredient (RP(BAI)) was obtained using the following formula:

RP(BAI) [%] = 100% - ruminal BAI release fraction [%]

Example: BAI release fraction [%] = 16%

RP(BAI) [%] = 100% - 16% = 84%.

The term total digestible BAI fraction [%] is used to denote the percentage of the initial amount of BAI [g] that is subject to digestion in all steps of the McDougall method. It was calculated with the following formula:

Total digestible BAI fraction [%] = ((initial amount of BAI [g] – residual amount of BAI after the 3rd step of the McDougall method [g]) / (initial amount of BAI [g])) x 100%.

Example: initial amount of BAI = 2.5 g
Residual amount of BAI after the 3rd step = 0.25 g

Total digestible BAI fraction (%) = ((2.5 g – 0.25 g) / (2.5 g)) x 100% = 90%

The total digestible BAI fraction [g/kg] was calculated with the following formula:

Total digestible BAI fraction [g/kg] = total digestible BAI fraction [%] x weight fraction of BAI in product [g/kg].

The term metabolizable amount of the biologically active ingredient m(BAI) is used to denote the fraction of the biologically active ingredient in grams per kg that was released from the tested products in the abomasum and small intestine in the rumen and thus can be utilized by the animal. Accordingly, the term metabolizable amount of the biologically active ingredient is the fraction of BAI that is available for metabolization and utilization by the animal. It was calculated with the following formula:

m(BAI) [g/kg] = total digestible fraction [g/kg] – (1000 – RP(BAI) [g/kg]) or

m(BAI) [g/kg] = total digestible fraction [g/kg] – ruminally released BAI fraction [g/kg].

The total digestible BAI fraction [g/kg] is the difference of the initial amount of BAI [g/kg] and the residual amount of BAI after the 3rd step of the McDougall method [g/kg]. The RP(BAI) [g/kg] is the residual amount of BAI [g/kg] after the 1st step of the McDougall method. The ruminally released BAI fraction [g/kg] is the amount of BAI released in the 1st step of the McDougall method.

The results of this test are given in Table 1.

VII. In vitro testing of the products 8 to 10 and C2

In a first trial, the products 8 to 10 according to the invention and product C2 not according to the invention were subjected to the in vitro testing described in Example V. The thus tested products are identified in Table 2 as initial products.

In a second trial, the products 8 to 10 according to the invention and product C2 not according to the invention were first subject to an abrasion test, followed by the in vitro test. The thus tested products are identified in Table 2 as products after abrasion test.

In a third trial, the products 8 to 10 according to the invention and product C2 not according to the invention were first subjected to a 1-week storage at 40°C and 75% relative humidity, followed by the in vitro test. The thus tested products are identified in Table 2 as products after 1-week storage.

Abrasion test:

In each case 15 g of the product were weighted in a sieve with a width of 1.25 mm. The exact weight of the sample taken was recorded with a level of precision of four decimal places. Then the sieve was placed in a shaking tower and the product particles were shaken with a frequency of 70 Hz for a period of 20 minutes. After completion of the 20 minutes, the particles were weighted again, and the loss of material was determined. The loss of material was considered for the in vitro tests.

Storage test:

In each case 15 g of the product was stored for 1 week in a storage chamber with a constant heat of 40 °C and a constant relative humidity of 75%.

In vitro testing:

The in vitro test is described above in Example V.

The results of the tests for the initial products, for the products after abrasion test, and for the products after 1-week storage are given in table 2.

VIII. In vitro testing of the products 11 to 13 and C2

The products 11 to 13 according to the invention and the product C2 not according to the invention were subjected to subjected to the in vitro testing described in Example V. The thus tested products are identified in Table 4 as initial products

In a second trial, the products 11 to 13 according to the invention and product C2 not according to the invention were first subjected to a 1-week storage at 40°C and 75% relative humidity, followed by the in vitro test (as described in Examples V and VI). The thus tested products are identified in Table 4 as products after 1-week storage.

The results of the tests for the initial products, and for the products after 1-week storage are given in table 4.

IX. Conclusions

The results in tables 1 and 3 show that the additional presence of cellulose provides the products according to the present invention with increased breaking force. Each of the products 1 to 7 and 11 to 13 comprising from 0.5 up to 5 wt.-% of cellulose has a higher breaking force than the comparison product C1. The results also suggest that the maximum of breaking force is achieved when the product comprises up to 2 wt.-% of cellulose. Further, it also appears that products comprising up to 2 wt.-% of cellulose show a maximum for the metabolizable fraction of the biologically active ingredient, a key factor for any type of sustained release or rumen protected product for the nutrition of ruminants.

The results in tables 2 and 4 show that the products 7 to 10 and 11 to 13 according to the invention lead to an improvement of the metabolizable BAI fraction, both after abrasion test and after 1-week storage at 40 °C and 75% relative humidity, compared to the product C2 without any additional cellulose. These results show that the products according to the present invention are more suitable for use under real-life conditions than the products not according to the invention.

Comp. No.	Lysin * HCl (BAI) [wt.-%]	Hydrogenated rapeseed oil [wt.-%]	Cellulose [wt.-%]	Stearic acid [wt.-%]	Rumen protection (BAI) [%]	Total digestible BAI fraction [%]	Metabolizable BAI fraction [g/kg]	Breaking force [N]
C1	50	50	0	0	79.8	78.0	311.22	20
1	50	49.50	0.5	0	77.3	83.6	323.12	25
2	50	49.25	0.75	0	72	88.2	317.52	30
3	50	49	1	0	73.5	88.9	326.71	34
4	50	48	2	0	73.7	86.9	320.23	29
5	50	47	3	0	67.7	90.2	305.33	24
6	50	46	4	0	66.4	88.8	294.82	22
7	50	45	5	0	46.8	93.1	217.86	23

Table 1: Tested products 1 to 7 according to the invention and comparative product C1, their compositions, and the results of their testing

Comp. No.	Info	Lysin * HCl (BAI) [wt.-%]	Hydrogenated rapeseed oil [wt.-%]	Cellulose [wt.-%]	Stearic acid [wt.-%]	Lecithin [wt.-%]	Rumen protection (BAI) [%]	Total digestible BAI fraction [%]	Metabolizable BAI fraction [g/kg]
C2	initial products	50	49.75	0	0	0.25	95.5	71.8	343
8		50	49.25	0.5	0	0.25	91.1	72.7	331
9		50	48.75	1	0	0.25	93.2	72.0	336
10		50	47.25	2	0	0.25	89.4	76.7	343
C2	products after abrasion test	50	49.75	0	0	0.25	93.4	72.5	339
8		50	49.25	0.5	0	0.25	90.0	82.0	370
9		50	48.75	1	0	0.25	91.5	78.6	360
10		50	47.25	2	0	0.25	88.6	84.6	375
C2	products after 1-week storage (40°C, 75% relative humidity)	50	49.75	0	0	0.25	81.7	81.1	331
8		50	49.25	0.5	0	0.25	76.5	88.6	339
9		50	48.75	1	0	0.25	79.0	84.8	335
10		50	47.25	2	0	0.25	74.7	92.6	346

Table 2: Tested products 8 to 10 according to the invention and comparative product C2, their compositions, and the results of their testing

Comp. No.	Lysin * HCl (BAI) [wt.-%]	Hydrogenated rapeseed oil [wt.-%]	Cellulose [wt.-%]	Stearic acid [wt.-%]	Rumen protection (BAI) [%]	Total digestible BAI fraction [%]	Metabolizable BAI fraction [g/kg]	Breaking force [N]
C1	50	50	0	0	79.8	78.0	311.22	20
11	50	40	1	8	73.3	95.3	280	21
12	50	40.5	1	8	82.0	92.2	302	32
13	50	40.75	1	8	83.3	85.6	285	24

Table 3: Tested products 11 to 13 according to the invention and comparative product C1, their compositions, and the results of their testing

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Comp. No.	Info	Lysin * HCl (BAI) [wt.-%]	Hydrogenated rapeseed oil [wt.-%]	Cellulose [wt.-%]	Stearic acid [wt.-%]	Lecithin [wt.-%]	Rumen protection (BAI) [%]	Total digestible BAI fraction [%]	Metabolizable BAI fraction [g/kg]
C2	initial products	50	49.75	0	0	0.25	95.5	71.8	343
11		50	40	1	8	1	73.3	92.2	349
12		50	40.5	1	8	0.5	82	92.3	378
13		50	40.75	1	8	0.25	83.3	85.6	357
C2	products after 1-week storage (40°C, 75% relative humidity)	50	49.75	0	0	0.25	81.7	81.1	331
11		50	40	1	8	1	66.2	96.8	320
12		50	40.5	1	8	0.5	76.9	94.6	364
13		50	40.75	1	8	0.25	77.9	87.3	340

Table 4: Tested products 11 to 13 according to the invention and comparative product C2, their compositions, and the results of their testing

Patent claims

1. A solid dispersion for feeding a ruminant comprising or consisting of

   i) from 40 wt.-% to 60 wt.-% of a biologically active ingredient, based on the total weight of the solid dispersion,

   ii) from 60 wt.-% to 40 wt.-% of a carrier, wherein the carrier comprises a mixture comprising from 35 wt.-% to less than 60 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.-% of cellulose, each based on the total weight of the solid dispersion.

2. The solid dispersion according to claim 1, wherein the biologically active ingredient is homogeneously distributed over the whole solid dispersion.

3. The solid dispersion according to claim 1 or 2, wherein the hydrogenated fat comprises or consists of a hydrogenated vegetable oil.

4. The solid dispersion according to any of claims 1 to 3, wherein the cellulose is cellulose powder and/or cellulose fiber.

5. The solid dispersion according to any of claims 1 to 4, wherein the carrier further comprises from more than 0 to 10 wt.-% of a fatty acid, based on the total weight of the solid dispersion.

6. The solid dispersion according to claim 5, wherein the fatty acid comprises or consists of a saturated fatty acid.

7. The solid dispersion according to claim 5 or 6, wherein the fatty acid comprises or consists of a C_{14} to C_{22} carboxylic acid.

8. The solid dispersion according to any of claims 1 to 7, wherein the carrier further comprises from more than 0 to 5 wt.-% of an emulsifier, based on the total weight of the solid dispersion.

9. The solid dispersion according to claim 8, wherein the emulsifier is a lecithin, a citrate and/or a lactate.

10. The solid dispersion according to any of claims 1 to 9, wherein the biologically active ingredient is selected from the list consisting of i) amino acids, derivatives of amino acids, and/or salts of amino acids and/or of their derivatives, ii) proteins, iii) peptides, iv) carbohydrates, v) vitamins, and derivatives of vitamins, vi) probiotic microorganisms, vii) prebiotic feeds, viii) choline, choline salts and/or derivatives thereof, ix) polyunsaturated fatty acids (PUFAs), derivatives thereof and/or salts thereof, and x) pharmaceuticals.

11. A process for the production of a solid dispersion according to any of claims 1 to 10, comprising the steps of

a) providing a liquefied mixture comprising from 40 wt.-% to 60 wt.-% of a biologically active ingredient, from 35 wt.-% to less than 60 wt.-% of a hydrogenated fat and from more than 0 to 5 wt.-% of cellulose, each based on the total weight of the solid dispersion to be prepared,

b) portioning the liquefied mixture provided in step a), and

c) cooling the portions obtained in step b) or allowing them to cool down to give the solid dispersion.

12. The process according to claim 11, wherein step a) further comprises the steps of

a1) providing a melt of a hydrogenated fat,

a2) adding an emulsifier to the melt of step a) to give a first mixture,

a3) adding a biologically active ingredient to the first mixture of step a2) to give a second mixture, and

a4) adding cellulose powder and/or cellulose fiber to the second mixture of step a3) to give a liquefied mixture.

13. The process according to claim 12, wherein the step a) further comprises adding a fatty acid to any of the mixtures.

14. A method for supplementing the diet of a ruminant with a biologically active ingredient, comprising the step of providing the ruminant with the solid dispersion according to any of claims 1 to 10, and/or the solid dispersion obtained by the process according to any of claims 11 to 13.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/067423

A. CLASSIFICATION OF SUBJECT MATTER

INV. A23K50/10 A23K20/105 A23K20/142 A23K20/158 A23K20/174
A61K9/10 A23K40/35 A61K9/00 A61K9/14 A61K31/00
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)
A23K

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017/143006 A1 (AWATI AJAY [GB] ET AL) 25 May 2017 (2017-05-25) paragraph [0001] - paragraph [0227]; claims; examples; tables	1-14
A	WO 2010/143066 A1 (MARS INC [US]; MARANGONI ALEJANDRO GREGORIO [CA]) 16 December 2010 (2010-12-16) page 1, line 11 - page 12, line 25; examples 1-2	1-14
A	US 5 068 108 A (FEZZI LUIGI [IT] ET AL) 26 November 1991 (1991-11-26) column 1, line 6 - column 4, line 46; claims; examples	1-14

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2024	23/08/2024

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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