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(54) Title: ANIMAL FEED COMPOSITION

(57) Abstract: The present invention relates to an animal feed composition comprising animal feed ingredients, wherein the animal feed composition comprises a total lipid content of from 20 to 50 wt. %, wherein the total lipid content comprises at least 40 wt. % of a liquid oil and 0.05 to 10 wt. % of an oil-binding ingredient, wherein the oil-binding ingredient comprises at least 20 wt. % wax-esters and optionally fat having a melting point above 50°C, and wherein the oil-binding ingredient is distributed within the composition. Moreover, the present invention relates to a process for the production of the animal feed composition and a use of the animal feed composition.

# Animal feed composition

The present invention relates to an animal feed composition, a process for the production of the same and a use of the animal feed composition.

High amounts of digestible lipids, in particular liquid oils, are often desirable in animal feed compositions, as they are particularly high in caloric value and beneficial for the growth and development of animals. The incorporation of high amounts of liquid oils in animal feed compositions is difficult to achieve since the liquid oil needs to be structurally retained in the feed composition.

Leakage of liquid oils results in a decreased provision of liquid oils to the animal, which in turn results in decreased nutritional effect and in production problems, such as clogging of the animal feed in storage or in transport pipes, eventually causing disruption of the feed stream to the animals.

The prior art describes different methods to reduce the tendency of leakage of liquid oils.

GB 2 232 573 describes animal feed pellets such as fish feeds, dog and cats foods in pellet form and textured soya protein pellets, which are prepared by a process in which edible liquid oil is added to the pellet and absorbed under conditions of reduced pressure.

WO 95/07028 describes a fodder containing lipids having a low melting point wherein the lipids are carried with in a crystalline structure formed by lipid additives such as other lipids, emulsifiers or a mixture of lipids and emulsifiers.

EP 0 668 025 A1 describes a fish feed comprising proteins, carbohydrates, fats, vitamins and trace elements whereby the fish feed prepared is provided with a coating consisting of an edible oil, which is liquid at least at 40°C and comprising a saturated triglyceride and/or saturated fatty acid thereof, having a melting point of above 40°C.

WO 98/49904 describes a method for preparing a high oil content fish feed pellets, including additives.

EP 1 825 762 A1 is directed to an animal feed composition comprising active compounds. The active compounds are strongly adhered to the feed by means of a fat coating and the animal feed has a low coating content.

High amounts of additives for preventing leakage currently need to be incorporated into the animal feed composition, to efficiently reduce the leakage of oils from an animal feed composition. As many of those additives for preventing leakage cannot be efficiently metabolized by certain animals, in particular fish, their presence significantly reduces the total caloric value of an animal feed composition. The additives for preventing leakage and amounts thereof are not effective enough to prevent further leakage, do not provide beneficial nutritional effects for the growth and development of animals and/or are used in amounts which are not practical or economically not viable.

Additionally, these additives for preventing leakage may require during production rapid cooling once the liquid oil is combined with the additive for preventing leakage. However, such rapid cooling conditions are often not met or are requiring high amounts of energy resources having an environmental and economical impact.

Also, these existing additives for preventing leakage may lose their effectiveness when the animal feed composition is stored and transported at elevated temperatures.

There is a need to overcome the disadvantages associated with the known animal feed compositions.

The invention relates to an animal feed composition, comprising animal feed ingredients, wherein the animal feed composition comprises a total lipid content

from 20 to 50 wt. %, wherein the total lipid content comprises at least 40 wt. % of a liquid oil and 0.05 to 10 wt. % of an oil-binding ingredient, wherein the oil-binding ingredient comprises at least 20 wt. % wax-esters and optionally fat having a melting point above 50°C, and wherein the oil-binding ingredient is distributed within the composition.

The animal feed composition can promote the growth and development of animals and it is a composition that comprises various animal feed ingredients. The animal feed composition according to the invention is used as aquafeed, for companion or farmed animals and in pet food. Typically, the animal feed composition is used for animals, such as cattle (dairy or beef), pig, horse, goat, sheep, rodents, chicken, goose, duck or turkey. Pet food is more dedicated to dogs or cats and aquafeed is suitable for fish (e.g., farm- and coastal-raised carp, tilapia, salmon, walleye, trout, sea-bass or catfish), and crustaceans (include without limitation, shrimp, lobster, crabs, crayfish, and prawns), and molluscs (include without limitation snails, clams, oysters, squid, octopus and mussels).The animal feed composition according to the invention is preferably used as aquafeed, preferably a fish feed composition.

According to the present invention, the animal feed composition comprises a total lipid content of from 20 to 50 wt. %. “Lipid” is a term well-known in the art and due to the high-energy value of lipids, high amounts of digestible lipids are desirable in the animal feed composition, as this may effectively promote the growth and development of animals.

The animal feed composition preferably comprises a total lipid content of from 25 to 48 wt. %, from 27 to 45 wt. % and from 30 to 40 wt. %.

According to the present invention, the total lipid content of the animal feed composition comprises at least 40 wt. % of a liquid oil. Therefore, the animal feed composition comprises at least 8 wt. % of a liquid oil.

The liquid oil can be one liquid oil or more liquid oils, i.e. mixture of more than one liquid oil. The liquid oil or the mixture of more than one liquid oil has a melting point of less than 20°C. In case of the mixture of more than one liquid oil has a melting point of less than 20°C it is understood that the final mixture of the more than one liquid oils has a melting point of less than 20°C.

High amounts of liquid oil in the animal feed composition are particularly preferred, as the high-energy value of liquid oils can promote the growth and development of the animals being fed with the animal feed composition. In addition, liquid oils comprise high amounts of unsaturated and poly-unsaturated fatty acids that are particularly beneficial for the growth and development of animals.

Preferably, the lipids provide an energy value in the animal feed composition of 900 to 4500 kcal / kg lipid in the feed composition, more preferably of 2000 to 4000 kcal / kg lipid in the feed composition and even more preferably of 2500 to 3500 kcal / kg lipid in the feed composition.

The total lipid content of the animal feed composition preferably comprises at least 50 wt. % and more preferably at least 60 wt. % of a liquid oil. The total lipid content preferably comprises up to 99.95 wt. %, up to 92 wt. %, or up to 90 wt. %, of a liquid oil.

The melting point can be determined according to the official AOCS method Cc 3-25.

The liquid oil is derived from a vegetable oil or an animal oil or mixtures thereof. Preferably, the liquid oil is a vegetable liquid oil derived from vegetable liquid oils or vegetable liquid oil blends, fractions thereof, fractions of palm oil, palm kernel oil, and/or mixture of two or more thereof. The vegetable liquid oils are selected from the group consisting of oils from cotton, corn, groundnut, linseed, olive, rape, canola, rice bran, sesame, safflower, soybean, sunflower, their corresponding mid or high oleic varieties or any variety with increased level of unsaturated fatty acids compared to the original seed variety, and mixture of two or more thereof. These

varieties with increased levels of unsaturated fatty acids can be obtained by natural selection or by genetic modification (GMO). Preferably the vegetable oil is selected from the group consisting of corn, rape, canola, soybean, sunflower, their corresponding high oleic varieties, and mixture of two or more thereof. The high oleic varieties are containing at least 40%, at least 50%, at least 60%, at least 70% and preferably at least 80% oleic acid in respect of the fatty acid profile.

Preferably the liquid oil is a vegetable oil, such as a sunflower oil, safflower oil, canola oil, rapeseed oil, rice bran oil, olive oil, soybean oil, corn oil, cotton oil, sesame seed oil, or palm olein, palm kernel olein, or an animal oil, such as fish oil or lard oil, or any mixture thereof. These liquid oils provide a nutritional profile that is particularly suitable for the growth and development of animals, particularly with regard to their fatty acid profiles, which means that they contain high amounts of unsaturated fatty acids. Particularly preferred liquid oil are sunflower oil, rapeseed oil, soybean oil, palm olein (mono- or bi-fractionated) and fish oil.

According to the present invention, the total lipid content of the animal feed composition comprises 0.05 to 10 wt. % of an oil-binding ingredient. Therefore, the animal feed composition comprises 0.01 to 5 wt. % of an oil-binding ingredient. An oil-binding ingredient is a component that reduces and/or prevents leakage of the liquid oil from the animal feed composition. It forms a kind of structure comparable to fat that is solid at ambient temperature, and it has the nutritional profile of liquid oils. At low concentrations of oil-binding ingredient, the structure is comparable to a fat that is spreadable at ambient temperature.

In one aspect of the invention, the total lipid content comprises 0.1 to 8 wt. %, preferably 0.2 to 6 wt. % and most preferably 0.5 to 4 wt. % of the oil-binding ingredient. Therefore, the oil-binding ingredient is lipid-based.

According to the present invention, the oil-binding ingredient comprises at least 20 wt. % wax-esters. Therefore, the animal feed composition comprises from 0.002 to 5 wt. % of wax-esters.

Wax-ester (i.e. wax) is a well-known terminology for the person skilled in the art and needs no further explanation. In case of doubt, wax-esters stand for esters of long chain fatty acids and long chain alcohol that are naturally present in the oil and can cause turbidity in the oil. Wax-esters are formed by long chain fatty alcohols linked to long chain fatty acids having a total carbon chain length of C36 to C60, either hydrogenated or non-hydrogenated. The long chain fatty alcohols preferably have a carbon chain length of C18 to C32, and the long chain fatty acids preferably have a carbon chain length of C18 to C28. Typical examples of these wax-esters include geranyl-geranyl esters, phytyl-esters and aliphatic wax esters and mixtures of two or more thereof. The wax can be of vegetable origin, animal origin and/or synthetic origin. Preferably, the wax is of vegetable origin such as sunflower wax, corn wax, rice bran wax, carnauba wax, candellila wax, berry wax or jojoba wax, or of animal origin, such as bees wax, lanolin, shellac or cetyl ester wax, or of synthetic origin. Preferably, the wax is of vegetable origin. More preferably, the wax is sunflower wax. Sunflower wax can have a melting point between 75 to 80°C.

In one aspect of the invention, the oil-binding ingredient comprises at least 25 wt. %, at least 30 wt. %, at least 40 wt. %, and at least 50 wt. % of the wax-ester. The oil-binding ingredient can entirely consist of a wax-ester.

According to the present invention, the oil-binding ingredient can optionally, comprise fat having a melting point above 50°C. In one aspect of the invention, the fat having a melting point above 50°C is a hydrogenated oil. Hydrogenated oils are oils that were subjected to a hydrogenation procedure, wherein a double bond of an unsaturated fatty acid, is reduced. The partial or full hydrogenation of carbon-carbon double bonds converts oils that are liquid at ambient temperatures into semi-solid or solid fats. In other word, the hydrogenation procedure increases the melting point of an oil.

Wax or wax-esters are more effective in its function as an oil-binding ingredient compared to fat having a similar melting point as the wax. By way of example, a fully hydro rapeseed oil is having a melting point of about 70°C and it is less

effective as oil-binding ingredient than sunflower wax. In terms of wt. %, less wax is required compared to hydrogenated oil to achieve the same effect, and a lower amount of oil-binding ingredient is required to reduce or prevent leakage of liquid oil from the animal feed composition. Therefore, the animal feed composition according to the present invention comprises higher amounts of nutritionally beneficial liquid oils compared to animal feed compositions of the prior art.

The hydrogenated oil can be hydrogenated high-erucic acid rapeseed oil, hydrogenated rapeseed oil, hydrogenated palm oil, hydrogenated soybean oil, hydrogenated sunflower oil, hydrogenated olive oil, hydrogenated coconut oil or hydrogenated fish oil or mixtures thereof.

In one aspect of the invention, the oil-binding ingredient is a combination of wax and hydrogenated oil. In another aspect of the invention, the ratio of wax to hydrogenated oil in the oil-binding ingredient is 80:20 to 20:80, 70:30 to 30:70, 60:40 to 40:60, 55:45 to 45:55 or is below 50:50.

In one aspect of the invention, the oil-binding ingredient further may comprise monoglycerides and/or diglycerides and/or triacylglycerides and/or emulsifiers, such as lecithin. These compounds may further contribute to the reduction or prevention of leakage of the liquid oil, and may lead to a reduction of the required amount of wax esters in the oil-binding ingredient.

In one aspect of the invention, the oil-binding ingredient may further comprise free fatty acids. Preferably, the free fatty acids are saturated fatty acids, such as stearic acid or palmitic acid. Free fatty acids may further contribute to the reduction or prevention of leakage of the liquid oil, and may lead to a reduction of the required amount of wax-esters in the oil-binding ingredient in the animal feed composition.

Without wishing to be bound by theory, in one aspect of the invention, the oil-binding ingredient forms a structure with the liquid oil. Therefore, the oil-binding ingredient crystallizes and has oil-binding properties and thus, immobilizes the

liquid oil in the structure. Thereby, the leakage of liquid oil from the animal feed composition is further reduced or prevented.

In the animal feed composition according to the invention, the oil-binding ingredient is distributed within the composition. The oil-binding ingredient is distributed within the animal feed composition so that the animal feed composition may comprise the maximum amount of liquid oil. By the distribution of the oil-binding ingredient within the animal feed composition, leakage of the liquid oil from the animal feed composition is reduced or prevented.

In one aspect of the invention, the oil-binding ingredient is uniformly distributed within the composition. The oil-binding ingredient is thus incorporated throughout the composition and not only in certain sections of the composition.

In one aspect of the invention, the animal feed composition further comprises animal feed ingredients such as proteins and/or carbohydrates. The specific amounts of proteins and/or carbohydrates in the animal feed composition are adjusted based on the individual needs of the animal being fed with the animal feed composition.

The term proteins relates to all kinds of proteins both of animal and vegetable origin. The term proteins further comprises all kinds of enzymes, peptides and single amino acids.

Enzymes may be added to the animal feed composition to increase the digestibility of certain ingredients of the animal feed composition by the animal that is fed with the animal feed composition. Examples for such enzymes are hydrolases or phytases. In addition, other enzymes may be used that allow the removal of certain toxins in the animal feed composition, such as the removal of mycotoxins.

Peptides that may be used in the animal feed composition may preferably be such that promote the growth and/or health of certain animals. Examples for such peptides may be peptides derived from gelatin or collagen.

Single amino acids in the animal feed composition are preferably such that cannot be synthesized in vivo by the animal itself that is fed with the animal feed composition.

The term carbohydrates relates to all kinds of mono-, di-, oligo-, and polysaccharides. This may include polysaccharides derived from cereals, such as wheat, corn, rice, tapioca, barley or oat. Further examples of polysaccharides are all kinds of starches including modified starches.

In one aspect of the invention, the animal feed composition further comprises minerals and/or vitamins. The selection of specific minerals and/or vitamins as well as their amounts in the animal feed composition are adjusted based on the individual needs of the animal being fed with the animal feed composition.

Examples for minerals in the animal feed composition are magnesium, manganese, calcium, phosphorus, sodium, potassium, iron, copper, zinc, selenium, iodine and molybdenum.

Due to the high lipid content in the animal feed composition, preferably lipid-soluble vitamins are added to the animal feed composition, such as that belonging to the group of vitamin A, vitamin D, vitamin E or vitamin K. Water-soluble vitamins may also be present in the animal feed composition, such as that belonging to the group of vitamin B or vitamin C.

In one aspect of the invention, the animal feed composition is a solid animal feed composition, preferably in form of a pellet. Preferably, the pellet has small pores, i.e. the pellet is a porous pellet. The use of an oil-binding ingredient for a porous animal feed composition is particularly effective in the reduction or prevention of liquid oil leakage.

In one aspect of the invention, the animal feed composition is an aquafeed composition, preferably a fish feed composition. In one aspect, the fish feed

composition is a salmon feed composition. Salmon fish requires particularly high amounts of liquids oils showing high amounts of unsaturated fatty acids for its growth and development and thus, the present invention is particularly suitable for salmon fish.

The fish feed composition preferably does not float on a water surface, but rather slowly sinks in the water. Preferably, the fish feed composition is dust-free, and stable in water. The size of the fish feed composition depends on the individual type of fish, and is known by a person skilled in the art.

In another aspect, the present invention relates to a process for the production of the animal feed composition according to the invention, the process comprises the steps of:

(a) melting lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C;

(b) adding the melted lipids to animal feed ingredients to obtain an animal feed composition.

In one aspect of the invention, the process for producing animal feed composition is comprising the following steps:

(a) mixing dry matter with an aqueous liquid to provide a mixture;

(b) extruding the mixture obtained from step (a);

(c) adjusting the moisture content of the extruded mixture obtained in step (b);

(d) melting the lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C;

(e) blending the melted lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C, and keeping the blend in a fully melted state;

(f) adding the blend of melted lipids obtained in step (e) to the extruded mixture obtained in step (c); and

(g) cooling the composition obtained in step (f).

In an aspect of the invention, the dry matter comprises animal feed ingredients.

In one aspect of the invention, before step (a), the dry matter is obtained by dosing together various dry ingredients, followed by mixing the ingredients to a homogenous mix, and, if required, grinding of the dry matter mix. The grinding may be conducted by passing the homogenous mix through a hammer mill, for example. Grinding of the homogenous mix to a proper particle size may facilitate the following preconditioning step (a), and may increase the water stability of the final product, which is particularly relevant for fish feed.

During step (a), the dry matter is preconditioned before extrusion step (b). The preconditioning step is important to supply the extruder with a uniformly mixed and hydrated material, preferably by mechanical stirring and adding saturated steam. Step (a) is preferably conducted at a temperature of 70 to 98 °C. The mixture obtained from step (a) preferably has a moisture content of from 20 to 35 wt. %.

In an aspect of the invention, the aqueous liquid in step (a) is water.

The selection of suitable extrusion conditions for step (b) is well known to a person skilled in the art. A person skilled in the art knows about the interaction of various extrusion parameters, such as the type of extruder as well as the specific process parameters, such as the screw speed, temperature, moisture content, raw material characteristics and die selection. During extrusion, the mixture obtained from step (a) is cooked under pressure, and finally expanded and formed at the extruder die.

In an aspect of the invention, a pellet is obtained after step (b).

In step (c), the extruded mixture obtained after step (b) is dried, once it has left the extrusion system. The drying step is necessary to remove the excess of water, and to return the product back to a shelf-stable moisture condition. For example, the extruded mixture may be dried in a crossflow dryer, in which moisture and heat of the mixture is exchanged with a perpendicular airflow. After step (c) the moisture content of the extruder mixture is preferably from 7 to 12 wt. %.

During step (d), the liquid oil and the oil-binding ingredient are fully melted, i.e. transformed to a liquid state.

In an aspect of the invention, melting the lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C in step (d) is conducted at a temperature between 50 to 90 °C, more preferably at a temperature between 70 to 80 °C for the oil-binding ingredient and optionally for the high melting fats and more preferably at a temperature between 50 and 60°C for the oils.

In subsequent step (e), the liquid oil and the oil-binding ingredient are blended and thus, a homogenous lipid melt comprising the liquid oil and the oil-binding ingredient is obtained.

In one aspect of the invention, keeping the blend in a fully melted state in step (e) is conducted at a temperature between 50 to 90 °C.

In step (f) the melted lipids are added to the extruded mixture obtained in step (c). Thereupon, the melted lipids are absorbed by the extruded mixture and thus, the melted lipids are incorporated in the extruded mixture.

In one aspect of the invention, adding the blend of melted lipids to the extruded mixture in step (f) is conducted in vacuum. Preferably, the pressure in step (f) is between 200 to 50 mbar, more preferably between 100 to 50 mbar.

After step (f), the composition is cooled during step (g). This step is required to allow the liquid oil and the oil-binding ingredient to reduce and prevent leakage of the liquid oil from the animal feed composition. Moreover, the animal feed composition can be prepared for packaging.

In one aspect of the invention, cooling the composition obtained in step (f) in step (g) is conducted by passing air at a temperature between 25 and 5°C by the

composition, preferably wherein the air is has a temperature between 20 and 5 °C, and more preferably wherein the cool air has a temperature between 15 and 5 °C.

In one aspect of the invention, cooling the composition obtained in step (f) in step (g) is conducted by passing air at a temperature between 40 and 15 °C, preferably between 35 and 20 °C, and more preferably between 30 and 20 °C.

In another aspect, the present invention relates to the use of wax-esters as oil binding ingredient of liquid oils in animal feed compositions.

In a further aspect, the present invention relates to the use of the animal feed composition according to the present invention for feeding an animal, preferably a fish.

In a further aspect, the present invention relates to a method of feeding an animal comprising the step of providing the animal feed composition according to the present invention to an animal, preferably a fish.

In view of the above, the present invention provides more efficient solutions that allow to reduce or preferably prevent the leakage of liquid oil from an animal feed composition compared to the prior art. The use of wax-esters as oil-binding ingredient was shown to be more efficient than other oil-binding ingredients used in the prior art. Therefore, the amount of oil-binding ingredient in the animal feed composition can be reduced, which allows the presence of higher amounts of digestible and nutritionally beneficial liquid oils in the animal feed composition. This, in turn, allows providing animals with an animal feed composition that is more nutritionally effective, particularly with regard to the growth and development of the animals. Therefore, the animal feed composition according to the invention also provides economic benefits over animal feed compositions known in the prior art.

The present invention provides improved animal feed compositions, which have a reduced, or preferably no leakage, of liquid oil therefrom, particularly during

storage, transport and/or upon providing the animal feed composition to the animal in the environment, even without having applied a rapid cooling during production and/or under warmer storage and transport conditions.

A particular objective technical problem underlying the present invention is to reduce the required amount of lipid additives in an animal feed composition, while the total caloric value remains at least comparable to the currently used animal feed compositions.

A further particular objective technical problem underlying the present invention is to provide an animal feed composition that comprises a higher proportion of lipids that can be metabolized by certain animals, preferably fish, while having a total lipid content comparable to currently used animal feed compositions.

A yet further particular objective technical problem underlying the present invention is to reduce the amount of lipid additives within an animal feed composition that cannot be metabolized by certain animals, preferably fish, and thus, to provide an animal feed composition that is more effective in promoting growth and development of these animals.

The present invention can be described by the following items:

1. An animal feed composition, comprising animal feed ingredients,
wherein the animal feed composition comprises a total lipid content of from 20 to 50 wt. %,
wherein the total lipid content comprises at least 40 wt. % of a liquid oil and 0.05 to 10 wt. % of an oil-binding ingredient,
wherein the oil-binding ingredient comprises at least 20 wt. % wax-esters and optionally fat having a melting point above 50 °C, and
wherein the oil-binding ingredient is distributed within the composition.

2. The animal feed composition according to item 1, wherein the total lipid content comprises at least 50 wt. % and preferably at least 60 wt. % of a liquid oil.

3. The animal feed composition according to item 1 and 2, wherein the total lipid content comprises 0.1 to 8 wt. %, preferably 0.2 to 6 wt. % and most preferably 0.5 to 4 wt. % of the oil-binding ingredient.

4. The animal feed composition according to any of items 1 to 3, wherein the oil-binding ingredient comprises at least 25 wt. %, preferably at least 30 wt. %, more preferably at least 40 wt. % and most preferably at least 50 wt. % of wax-esters.

5. The animal feed composition according to any of items 1 to 4, wherein the liquid oil is one or more oil(s) having a melting point of less than 20°C.

6. The animal feed composition according to any of items 1 to 5, wherein the liquid oil is, a vegetable oil, such as a sunflower oil, safflower oil, canola oil, rapeseed oil, rice bran oil, olive oil, soybean oil, corn oil, cotton oil, sesame seed oil or palm oil, or an animal oil, such as fish oil or lard oil, or any mixture thereof.

7. The animal feed composition according to any of items 1 to 6, wherein the oil-binding ingredient further comprises monoglycerides and/or diglycerides and/or triacylglycerides and/or emulsifiers.

8. The animal feed composition according to any of items 1 to 7, wherein the oil-binding ingredient reduces and/or prevents leakage of the liquid oil.

9. The animal feed composition according to any of items 1 to 8, wherein the oil-binding ingredient further comprises free fatty acids.

10. The animal feed composition according to any of items 1 to 9, wherein the wax-esters comprises long chain fatty alcohols linked to long chain fatty acids having a total carbon chain length of C36 to C60 either hydrogenated or non-hydrogenated.

11. The animal feed composition according to items 10, wherein the long chain fatty alcohols have a carbon chain length of C18 to C32, and the long chain fatty acids have a carbon chain length of C18 to C28.

12. The animal feed composition according to any of items 1 to 11, wherein the wax-ester is of vegetable origin such as sunflower wax, corn wax, rice bran wax, carnauba wax, candellila wax, berry wax or jojoba wax, or of animal origin, such as bees wax, lanolin, shellac or cetyl ester wax, or of synthetic origin.

13. The animal feed composition according to item 12, wherein the wax-ester is of vegetable origin and more preferably is sunflower wax.

14. The animal feed composition according to any of items 1 to 13, wherein the fat having a melting point above 50°C is hydrogenated oil selected from high-erucic acid rapeseed oil, hydrogenated rapeseed oil, hydrogenated palm oil, hydrogenated soya bean oil, hydrogenated sunflower oil,

hydrogenated olive oil, hydrogenated coconut oil or hydrogenated fish oil or mixtures thereof.

15. The animal feed composition according to items 1 to 14, wherein the ratio of wax to fat having a melting point above 50°C in the oil-binding ingredient is 80:20 to 20:80, 70:30 to 30:70, 60:40 to 40:60,55:45 to 45:55 or is below 50:50.

16. The animal feed composition according to any of items 1 to 15, wherein the animal feed ingredients comprise proteins and/or carbohydrates.

17. The animal feed composition according to any of items 1 to 16, wherein the animal feed ingredients comprise minerals and/or vitamins.

18. The animal feed composition according to any of items 1 to 17, wherein the composition is an aquafeed composition, preferably a fish feed composition.

19. The animal feed composition according to item 18, wherein the composition is a salmon feed composition.

20. The animal feed composition according to any of items 1 to 19, wherein the composition is a solid animal feed composition.

21. The animal feed composition according to any of items 1 to 20, wherein the composition is in form of a pellet.

22. A process for the production of an animal feed composition according to the preceding items, the process comprises the steps of:

(a) melting lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C;
(b) adding the melted lipids to animal feed ingredients to obtain an animal feed composition.

23. The process according to item 22, the process comprises the steps of

a) mixing dry matter with an aqueous liquid to provide a mixture;

b) extruding the mixture obtained from step (a);

c) adjusting the moisture content of the extruded mixture obtained in step (b);

d) melting the lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally hydrogenated oil;

e) blending the melted lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C, and keeping the blend in a fully melted state;

f) adding the blend of melted lipids obtained in step (e) to the extruded mixture obtained in step (c); and

g) cooling the composition obtained in step (f).

24. The process according to item 23, wherein the dry matter comprises animal feed ingredients.

25. The process according to items 23 and 24, wherein in step (a) the aqueous liquid is water.

26. The process according to items 23 to 25, wherein after step (b) a pellet is obtained.

27. The process according to items 23 to 26, wherein step (e) keeping the blend in a fully melted state is conducted at a temperature between 50 to 90°C.

28. The process according to any of items 23 to 27, wherein step (f) adding the blend of melted lipids to the extruded mixture is conducted in vacuum.

29. The process according to any of items 23 to 28, wherein step (g) cooling the composition obtained in step (f) is conducted by passing cool air by the composition, preferably wherein the cool air has a temperature between 5 to 25 °C, more preferably wherein the cool air has a temperature between 5 and 20 °C and even more preferably wherein the cool air has a temperature between 5 and 15 °C.

30. An animal feed composition obtainable by the process according to any of items 22 to 29.

31. Use of the animal feed composition according to items 1 to 21 for feeding an animal, preferably a fish.

32. Use of wax-esters as oil binding ingredient of liquid oils in animal feed compositions.

33. A method of feeding an animal comprising the step of providing the animal feed composition according to any of items 1 to 21 to an animal, preferably a fish.

Examples

Preparation of an animal feed composition

570 g proteins (from fish meal, soybean and wheat proteins), 170 g carbohydrates (from wheat carbohydrates), 75 g minerals (Iron, Zinc, Copper, Manganese, Phosphorus and other trace components) and 60 g lipids (from fish meal) were dosed together and mixed to form a homogenous dry matter. The dry matter was then preconditioned with water and steam at a temperature of 90 °C to a final moisture content of 29 wt. %. The obtained mixture was extruded with a Wenger X85 extruder at a temperature of 120°C, a pressure of 9000 mbar, and a screw speed of 555 rpm. The extruded mixture (pellet) was then dried to a moisture content of 8.5 wt. % by means of a pilot scale two-pass belt drier. After drying, the pellet had a sample weight of 1000 g. Independent from each other, liquid oil (70% crude rapeseed oil and 30% crude fish oil), hydrogenated high-erucic acid rapeseed oil (HERO), hydrogenated rapeseed oil and sunflower wax was fully melted at a temperature of 80 °C.

The following lipids were then prepared according to Table 1. When an oil-binding ingredient was added, the percentage proportion of added liquid oil based on total lipid content, decreased by the percentage proportion of added oil-binding ingredient.

Table1.

| | Comparative Example 1 | Comparative Example 2 | Comparative Example 3 | Example 1 | Example 2 |
|---|---|---|---|---|---|
| Liquid oil (70% crude rapeseed oil / 30% crude fish oil) | 100% | 98% | 98% | 99.25% | 99.5% |
| Oil-binding ingredient | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| HERO | - | 2% | - | - | - |
| Hydro rapeseed oil | - | - | 2% | - | - |
| Sunflower wax | - | - | - | 0.75% | 0.5% |

The prepared lipid (of either Comparative Examples 1 to 3, or Examples 1 to 2) was kept in a fully melted state at a temperature of 70 to 80 °C. 480 g of the melted lipid was then added to the pellet, and absorbed by the pellet under vacuum at a pressure of 50-100 mbar. The pellet enriched in lipids was then cooled by means of 2 different cooling protocols, *i.e.* a fast cooling protocol using forced air at a temperature of 6°C passing over the pellets or a slow cooling protocol at a temperature of 20°C overnight, not using forced air. After the cooling protocols all samples were stored at 6°C. The individual compositions of the final animal feed compositions according to the Comparative Examples and the Examples according to the invention are presented in Table 2. As can be observed from Table 2, all Examples show the same amounts of carbohydrates, proteins, ash, moisture, and total lipid content.

Table 2 shows the nutritional composition (wt. %) of the animal feed composition and energy value [kcal/kg] provided by the lipids in the feed.

Table 2.

| | Comparative Example 1 | Comparative Example 2 | Comparative Example 3 | Example 1 | Example 2 |
|---|---|---|---|---|---|
| composition of the feed pellet | | | | | |
| % carbohydrates | 38.5 | | | | |
| % proteine | 11.5 | | | | |
| % ash | 5 | | | | |
| % moisture | 37.6 | | | | |
| % lipid content | 36.8 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Energy value provided by lipids in kcal/kg feed | 3146 | 2975 | 2975 | 3082 | 3104 |

Storage and preconditioning of the animal feed composition

The prepared feed composition (of Comparative Examples 1 to 3, and Examples 1 to 2) was stored during 1 week at a temperature of 6 °C. Prior to measuring the oil leakage, the animal feed compositions were preconditioned during 24 hours at a temperature of 20°C and 30°C, respectively. The latter temperature (30 °C) was used to evaluate the ability of the oil-binding ingredient to prevent oil seepage when pellets are stored under elevated temperature conditions, for example during summer time.

Determination of oil leakage from an animal feed composition

At first, the sample weight of the pellets was determined (A), and the lipid content of the final pellet (C) was determined by means of Low-Field Nuclear Magnetic Resonance (LFNMR) or Near-infrared spectroscopy (NIR). The animal feed pellet was then centrifuged at 100 G at a temperature of 20, respectively 30°C for 3 min (Thermo Scientific SL 16R). The sample weight of the pellet after centrifugation was determined (B). From the above-mentioned data, the relative lipid loss was calculated as follows:

Relative lipid loss [%] = 100 * ((A-B)*100 / A*C)
A = average sample weight before the test (g)
B = average sample weight after the test (g)
C = average sample lipid content (%) measured according LFNMR or NIR

The results of the relative lipid loss of the pellets according to the Comparative Examples and according to the Examples of the invention are presented in Table 3.

Table 3. Relative oil loss expressed in %

| | Comparative Example 1 | Comparative Example 2 | Comparative Example 3 | Example 1 | Example 2 |
|---|---|---|---|---|---|
| Fast cooling; conditioning at 20°C | 18.6 | 1.8 | 3.6 | 1.8 | 3.1 |
| Fast cooling; conditioning at 30°C | 22.1 | 1.8 | 7.1 | 4 | 5 |
| Slow cooling; conditioning at 20°C | 20.9 | 1.8 | 5.9 | 1.3 | 2.3 |
| Slow cooling; conditioning at 30°C | 22.4 | 8.9 | 8.1 | 1.8 | 3.1 |

From Table 3, it can be observed that, when produced and stored under ideal conditions (simulated by fast cooling and conditioning at 20°C), animal feed compositions containing only about 1/3 or less of the oil-binding ingredient according to the present invention (Examples 1 to 2) show a similar or even lower oil loss compared to the animal feed compositions containing existing oil-binding ingredients (Comparative Examples 1 to 3). This shows that the oil-binding ingredient according to the invention is more effective than existing solutions under ideal conditions. Due to a lower dosage of oil-binding ingredient needed, the caloric value of the animal feed composition according to the present invention is higher (see Table 2). This results into a cost saving in the production of the animal feed composition and an added value of the animal feed composition.

By simulating sub-ideal, i.e. slow cooling conditions at production, and an elevated storage temperature (30 °C), it can be observed that the oil loss from the animal feed composition according to the present invention is much less than that from the animal feed composition containing existing oil-binding solutions, although the

concentration of oil-binding ingredient according to the invention is much lower. This shows that the oil-binding ingredient according to the invention is particularly effective under difficult production and/or storage conditions. Consequently less cooling is needed during production and storage, which represents a significant energy saving.

## Claims

1. An animal feed composition comprising animal feed ingredients,
wherein the animal feed composition comprises a total lipid content of from 20 to 50 wt. %,
wherein the total lipid content comprises at least 40 wt. % of a liquid oil and 0.05 to 10 wt. % of an oil-binding ingredient,
wherein the oil-binding ingredient comprises at least 20 wt. % wax-esters and optionally fat having a melting point above 50°C, and
wherein the oil-binding ingredient is distributed within the composition.

2. The animal feed composition according to claim 1, wherein the total lipid content comprises at least 50 wt. % and preferably at least 60 wt. % of a liquid oil.

3. The animal feed composition according to claim 1 and 2, wherein the total lipid content comprises 0.1 to 8 wt. %, preferably 0.2 to 6 wt. % and most preferably 0.5 to 4 wt. % of the oil-binding ingredient.

4. The animal feed composition according to any of claims 1 to 3, wherein the oil-binding ingredient comprises at least 25 wt. %, preferably at least 30 wt. %, more preferably at least 40 wt. % and most preferably at least 50 wt. % of the wax-esters.

5. The animal feed composition according to any of claims 1 to 4, wherein the liquid oil is a vegetable oil, such as a sunflower oil, safflower oil, canola oil, rapeseed oil, rice bran oil, olive oil, soybean oil, corn oil, cotton oil, sesame seed oil or palm oil, or an animal oil, such as fish oil or lard oil, or any mixture thereof.

6. The animal feed composition according to any of claims 1 to 5, wherein the wax-ester is of vegetable origin such as sunflower wax, corn wax, rice bran wax, carnauba wax, candellila wax, berry wax or jojoba wax, or of animal

origin, such as bees wax, lanolin, shellac or cetyl ester wax, or of synthetic origin.

7. The animal feed composition according to claim 6, wherein the wax-ester is of vegetable origin and more preferably is sunflower wax.

8. The animal feed composition according to any of claims 1 to 7, wherein the fat having a melting point above 50°C is a hydrogenated oil selected from hydrogenated high-erucic acid rapeseed oil, hydrogenated rapeseed oil, hydrogenated palm oil, hydrogenated soybean oil, hydrogenated sunflower oil, hydrogenated olive oil, hydrogenated coconut oil or hydrogenated fish oil or mixtures thereof.

9. The animal feed composition according to any of claims 1 to 8, wherein the composition is an aquafeed composition, preferably a fish feed composition.

10. The animal feed composition according to any of claims 1 to 9, wherein the composition is in form of a pellet.

11. A process for the production of an animal feed composition according to the preceding claims, the process comprising the steps of

(a) melting lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C;
(b) adding the melted lipids to animal feed ingredients to obtain an animal feed composition.

12. The process according to claim 11, the process comprising the steps of:

(a) mixing dry matter with an aqueous liquid to provide a mixture;

(b) extruding the mixture obtained from step (a);

(c) adjusting the moisture content of the extruded mixture obtained in step (b);

(d) melting the lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C;

(e) blending the melted lipids comprising the liquid oil and the oil-binding ingredient comprising wax-esters and optionally fat having a melting point above 50°C, and keeping the blend in a fully melted state;

(f) adding the blend of melted lipids obtained in step (e) to the extruded mixture obtained in step (c); and

(g) cooling the composition obtained in step (f).

13. Use of the animal feed composition according to claims 1 to 10 for feeding an animal, preferably a fish.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/067957

A. CLASSIFICATION OF SUBJECT MATTER
INV. A23K20/158 A23K50/80 A23K10/22 A23K10/30 A23K40/25
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 C11C

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, FSTA, WPI Data

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

[X] See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 1 August 2019 | 08/08/2019 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Alevisopoulos, S |

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