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(54) **Feed composition, method for the preparation thereof and use of a binder in a feed composition.**

(57) The invention relates to a feed composition comprising one or more base feed materials and a binder, wherein the feed composition is preferably a total mixed ration or a partial mixed ration. The invention also relates to a method for the preparation of the feed composition, comprising mixing one or more base feed materials, preferably comprising one or more components selected from the group consisting of roughages, mash, dry and moist by-products, minerals, trace elements, vitamins, and additives; with a binder, and optionally water to obtain a feed composition. In addition, the invention relates to a use of a binder in a feed composition for the reduction of feed sorting in livestock, preferably a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, more preferably the starchbased binder is a pre-gelatinized starch-based binder.

Title: Feed composition, method for the preparation thereof and use of a binder in a feed composition.

Description

The present disclosure relates to a feed composition, to a method for the preparation of said feed composition, and to the use of a binder in a feed composition.

Background

It is common to provide dairy cows a mixed ration, with the aim to cover the nutritional needs of these for an optimal milk production. A mixed ration, such as a partial or total mixed ration (PMR/TMR), should be homogeneous and should not be susceptible for feed sorting. However, the homogeneity and adhesiveness of prior art mixed ration is often not optimal and susceptible for feed sorting. Feed sorting is the ability of livestock to sort the ration in favor of the more palatable parts of the ration, which are usually the small particles of concentrate feeds.

Mature dairy cows tend to sort for the smaller feed components of their total- or partial mixed ration (TMR/PMR), discriminating against longer forage components, which are high in fiber. Sorting of a TMR/PMR can mean that the dominant cows actually consume much more fermentable carbohydrates than intended, and less effective fiber. This in turn may increases the risk of depressed rumen pH and sub-acute ruminal acidosis (SARA). Imbalanced nutrient intake and altered rumen fermentation as a result of feed sorting, can affect digestion efficiency and production. Sorting of a TMR/PMR can also reduce the nutritive value of what remains in the feed bunk and which is ingested by lower-rank cows, particularly in the later hours after feed delivery. Feed sorting depends inter alia on forage inclusion rate, particle size, and dry matter content (see Miller-Cushon and T. J. De Vries, J. Dairy Sci. 100, (2017), 1-12). The prior art has focused on controlling these characteristics in order to reduce feed sorting.

There is a need of a feed composition in which feed sorting in mixed ration is reduced. Moreover, there is a need of an additive that can be used for reducing feed sorting.

Summary of the invention

In a first aspect, the present invention relates to a feed composition comprising one or more base feed materials and a binder. The feed composition is preferably a total mixed ration or a partial mixed ration.

In a second aspect, the present invention relates to a method for the preparation of a feed composition, comprising mixing one or more base feed materials with a binder and optionally water to obtain a feed composition. The one or more base feed materials may comprise one or more components selected from the group consisting of roughages, mash, minerals, trace elements, vitamins, and additives. The binder is for example a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, preferably the starch-based binder is a pre-gelatinized starch-based binder.

In a third aspect, the present invention relates to the use of a binder in a feed composition for the reduction of feed sorting in livestock. The binder is for example a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, preferably the starch-based binder is a pre-gelatinized starch-based binder.

Definitions

The following definitions are used in the present description.

“Base feed materials” as used in the present description means: the feed components that are used to prepare a feed composition. Examples thereof are roughages, mash, pelleted mash, minerals, trace elements, vitamins, and additives.

“Concentrate” as used in the present description means: a combination of base feed materials, with the exception of roughages.

“Mixed ration” as used in the present description means: a feed for animals, preferably cattle, which comprises a blend of base feed materials. Preferably, it is not subjected to densification or pelletizing or any type of pressure. Preferably it is a “loose” mix, obtained by mixing of several base feed materials. In the present application a mixed ration is also understood as a feed composition.

“Total mixed ration” or “TMR” as used in the present description means: a feed for animals, preferably cattle, which comprises a blend of all required base feed materials. A TMR is a single well-mixed basic ration with a balanced ration of base feed materials such as roughage, vitamins and minerals. A TMR is adapted to the groups' average feed needs. It is a complete ration which provides adequate nourishment to meet the needs of the animal, preferably dairy cows. Each bite consumed contains the required combination of nutrients (energy, protein, minerals and vitamins) needed by the animal.

"Partial mixed ration" or "PMR" as used in the present description means: a feed for animals, preferably cattle, which comprises a blend of several base feed materials. In the PMR all roughages and a part of a concentrate is mixed into the ration. The remainder concentrate is provided to the animals separately. In principle, PMR can be used to provide a different feed for each animal.

"Roughage" as used in the present description means: fiber-rich plant-based materials. Examples thereof are pasture grasses, forages, hays, silages, by-products of different processes, and combinations thereof.

Specific examples of pasture grasses include: grass, alfalfa grass, Bermuda grass
Specific examples of forages include: (chopped) straw, such as wheat straw, barley or oat straw.

Specific examples of hays include: grass hay, alfalfa hay, timothy hay, grass seed hay.

Specific examples of silages include: maize (corn) silage, grass silage, barley silage, alfalfa silage, millet silage, oat silage, hemp silage, field/faba beans silage, and sorghum silage.

Specific examples of byproducts of different processes include: shells, soy hulls, corn gluten feed, and wheat midds, brewers grains, beet press pulps, pea fibers, chicory (pens), cabbage, potato, wheat distiller grain, onion pulp, sugar beet pulp.

"Mash" or "pelleted mash" as used in the present description means: ground meal of cereal grains and cereal grain products. Examples of cereals are maize (corn), milo, wheat, barley, rye, oat, wheat flour, unpolished rice, millet, soybean flour, cassava, soybean meal, dehulled soybean meal, rapeseed extracted meal, peanut extracted meal, linseed oil meal, sesame oil meal, coconut oil meal, sunflower oil meal, safflower oil meal, palm kerned oil meal, kapok oil meal. Pelleted mash is mash that is processed into pellet shape and can comprise one or more of the above ground meals.

"Minerals" as used in the present description means: minerals as such, Na, K, Mg, Cl and S, or salts thereof. Examples of mineral salts are sodium chloride (source of sodium) or calcium carbonate (source of calcium), dicalcium phosphate (source of calcium and phosphorus), tricalcium phosphate (source of calcium and phosphorus), or mineral feeds which are a source of minerals, such as limestone powder (source of calcium), and oyster shell (source of calcium).

"Trace elements" as used in the present description means: micronutrients, such as copper, selenium, manganese, cobalt, iodine, iron, and zinc.

"Vitamins" as used in the present description means: an organic molecule (or related set of molecules) that is an essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism. Examples of vitamins are vitamin A, vitamin D3, and vitamin E.

"Additives" as used in the present description means: any additive that is suitable for use in an animal feed, preferably additives stimulate the rapid and healthy growth of said animal, such as an antibiotic, preservative, enzyme, antifungal agent, antioxidant, colorant, sweetener, perfume, binder, anti-protozoic, anti-mold/yeast and supporter/promoter rumen fermentation.

"Binder" as used in the present description means: an additive that is suitable for use in an animal feed that stimulates the adherence of feed particles. Examples of binders are starch-based binders, pectin-based binders, protein-based binders or pre-gelatinized starch-based binders, or a combination of two or more thereof.

"Pre-gelatinized starch" as used in the present description means: starch which has been cooked and then dried, for instance in the starch factory on a drum dryer or in an extruder, making the starch cold-water-soluble. Starch gelatinization is a process of breaking down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites (the hydroxyl hydrogen and oxygen) to engage more water.

"Extruded" as used in the present description means: treated by a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the material, and are then cut into a specific size by blades.

"Penn State Particle Separator (PSPS)" as used in the present description means: a particle separator that is used for determining the particle size distribution of a feed composition (TMR/PMR) and/or roughage. A stack of five plastic separator boxes is used, the top four each having different size sieves in the bottom thereof. The top/upper sieve is provided with the largest openings (pores or holes), having a diameter of 19 millimeter (approximately 0.75 inches). Any particle that is smaller will fall into the second sieve below. The second sieve has the medium-sized holes, having a diameter of 8 millimeter (approximately 0.31 inches). Any particle that is smaller will fall into the third sieve below, having a diameter of 4 millimeter (approximately 0.16 inches). Any particle that is smaller will fall into the lower sieve below. The lower sieve has the small-sized holes, having a diameter of 1.18 millimeter (approximately 0.05 inches). Any particle that is smaller will fall into the solid bottom box and can be retrieved. An amount, e.g. 3 pints (1.4 liter) of the material to be tested is added to the upper sieve. The stack of boxes is shaken in one direction 5 times on a flat surface. Then, the stack is turned one-quarter. Care should be taken not to provide vertical motion during shaking. This process should be repeated 7 times. In total there will be 8 sets or 40 shakes, rotating the separator after each set of 5 shakes. The force and frequency of shaking must be enough to slide particles over the sieve surface, allowing those smaller than the pore size to fall through. The shake frequency should be at least 1.1 Hz (approximately 1.1 shake per second) with a stroke length of 7 inches (or approximately 17 cm). After shaking is completed, the material on each sieve and on the bottom box is weighted to determine the fraction. A description of the shaking procedure is described in P. J. Kononoff et.al. *"Modification of the Penn State Forage and Total Mixed Ration Particle Separator and the Effects of Moisture Content on its Measurements"*, J. Dairy Sci. 86(5), 2003, 1858-1863.

"Airstream sieving" as used in the present description means a way of sieving using a particle separator for determining the particle size distribution of powders. It is carried out using ISO 3310-1 (2016) Test sieves – Technical requirements and testing – Part 1: Test sieves of metal wire cloth The particle size is expressed in a percentage, being the percentage of sample that fits through a sieve of a certain mesh size. The sample material is brought onto a sieve and weighted. The sieve is then placed on a sieving machine. There is a permanent under pressure achieved in the chamber above the sieve, this allows a stream of air to pass through the sieve from below. This airstream stirs up the particles, allowing for separation. The particles with a size smaller than the mesh size fall through the sieve. The sample material left behind on the sieve is then weighted to obtain a weight percentage of particles with a size larger than the current mesh size. This experiment can be repeated for other mesh sizes.

"Feed sorting behavior score" or "FSS" as used in the present description means: score regarding feed sorting and determined by observation of the animals' behavior. Feed sorting behavior was scored on a scale from 1 to 10. This was scored according the following method:

Before and after unloading the feeding wagon, attention was paid to behavior of the dairy cows. First of all, the reaction of the cows to the sound of the feeding wagon was scored on a scale from 1 to 10. The other factors were based on the feeding behavior of the dairy cows, such as moving aside the mixed ration, licking behavior under the ration, dropping feed out of the mouth, or digging holes in the ration in order to ingest small particles from the ground. These factors were all scored on a scale from 1 to 10.

The reaction of the cows on the sound of the feeding wagon was scored 1 when all cows gathered at the feeding gate, and 10 when no cow showed increased interest in the fresh ration being fed at the feeding gate. Moving aside the ration, or throwing the ration out of reach was scored 1 when almost all the cows moved or threw around the ration with their snout and 10 when almost none of the cows moved the ration around. Moving around the ration must not be confused with digging holes in the ration. Digging holes in the mixed ration is when cows use their snout to create holes into the ration in order to be able to lick the small particles from the floor. This was scored 1 when all cows showed digging behavior, and scored 10 when none of the cows showed digging behavior.

Licking behavior was scored 1 when all the cows where licking under the ration (licking and swallowing small particles) and 10 when none of the cows were licking on the floor.

The scores of these factors were averaged into a feed sorting behavior score (FSS),_ ranging from 1 to 10 where 1 stands for severe feed sorting and 10 means no feed sorting behavior at all. This average refers to a mean average of the scores of these factors.

“Cow health parameters” as used in the present description refer to characteristics such as body condition score, manure consistency score, rumen fill score and the rumination score. These characteristics were determined by the standardized method described in the practical guide Jan Julsen and B. Klein Swormink *‘Koesignalen’*, Hulsen, 2013.

Body condition score was scored on a scale from 1 to 5, where 1 stands for very skinny, 3 stands for perfect condition and 5 stand for too fat.

Manure consistency score was scored on a scale from 1 to 5 where 1 stands for aqueous manure, 3 stand for perfect consistency (not too thin, not too thick) and 5 stand for very thick manure.

Rumen fill score was scored on a scale from 1 to 5 where 1 stands for a hollow left flank behind the ribs, 3 stand for a perfectly filled rumen and 5 stand for a swollen left flank where the transition from rib to flank is not visible.

Rumination score was scored by counting the number of chewings/mastications between two ructi. Ructi is plural of ructus, and this could be described as belching or burping.

‘Feed efficiency’ as used in the present description provides information regarding the efficiency of the feed. It is based on the ratio between the milk production and the feed intake on dry matter basis.

For milk production, the fat and protein corrected milk (FPCM) per day is taken, which is calculated in the following way:

FPCM per day = total milk (kg) * (0.337 + 0.116 * % milk fat + 0.06 * % milk protein),

wherein total milk (kg) is a sum of the total amount of milk (kg) produced by all lactating cows, and wherein % milk fat and % milk protein are wt.% and are determined on the total amount of milk (e.g. in the milk tank). These values can for instance be obtained from the farm management systems.

For feed intake on dry matter basis, the total daily feed intake on dry matter basis (kg) is taken, which is calculated by subtracting the amount of residual feed 24 hours after feeding (corrected for deviations in feeding time) from the total amount of feed (registered per feed ingredient) fed to all lactating cows.

The feed efficiency can then be determined by the following formula:

$$Feed\ efficiency = \frac{FPCM\ (kg)}{Feed\ intake\ (kg\ DM)}$$

Detailed description of the invention

In a first aspect, the present invention relates to a feed composition comprising one or more base feed materials and a binder. The feed composition is preferably a total mixed ration or a partial mixed ration. The binder is for example, a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, preferably the starch-based binder is a pre-gelatinized starch-based binder.

The feed composition may comprise at least 5 wt.% water based on the total weight of the feed composition, preferably at least 15 wt.%, more preferably at least 25 wt.%. This water may be already present in the one or more base feed materials or may be added to one or more base feed materials when preparing the feed composition.

The feed composition according to the present disclosure reduces feed sorting of livestock, as adherence of the base feed materials is increased. The present inventors have also noted that the feed composition according to the present disclosure exhibits reduction of feed sorting even at temperatures higher than approximately 20 °C and windy weather conditions.

The effect of the binder is to bind the particles of the one or more base feed material(s).

In an embodiment, the one or more base feed materials are loose materials, in other words not pressed into pellets. The effect thereof is that small base feed materials particles, i.e. particles having a size of less than 1.18 mm, can fall down or can be separated by shaking, from the bigger base feed materials particles.

The binder may be obtained by methods known by the skilled person. For example, by subjecting a starch-based binder to acidification at high temperature in an extruder, as described in patent US 3,565,651. It is also possible to extrude a starchy-material at temperature sufficient to gelatinize the starch. The effect of the pre-gelatinization of the starch in the binder is that this provides excellent binding of loose base materials.

In an embodiment, the feed composition is a Total Mixed Ration (TMR), in which a single feed is provided, which can be directly feed to the animals. In the TMR, the feed composition comprises one or more base feed materials in such manner that it provides adequate nourishment to meet the needs of dairy cows. Each bite consumed contains the required combination of nutrients (energy, protein, minerals and vitamins) needed by the cow. This means that all forages, concentrates, protein supplements, minerals and vitamins are mixed and offered as a single feed.

In an embodiment, the feed composition is a Partial Mixed Ration (PMR), in which the farmer has flexibility in mixing differing amounts of the concentrate to e.g. roughages to enable him to tune the nutritional value depending on the need of the animal(s). In this case, a part of the concentrate is provided to the animals in the mixed ration and the rest of the concentrate is provided to the animals separately, for example, in concentrate boxes or in the milking parlour.

In an embodiment, the one or more base feed materials comprise one or more components selected from the group consisting of roughages, mash, minerals, trace elements, vitamins, and additives. Preferably at least roughages are present. These components provide the required nutritional value.

In an embodiment, the feed composition is a mixed ration comprising between 50 and 100 wt.% of roughages, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration comprising between 50 and 100 wt.% of roughages, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Partial Mixed Ration comprising between 60 and 100 wt.% of roughages, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration comprising between 0 and 50 wt.% of mash, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Partial Mixed Ration comprising between 0 and 40 wt.% of mash, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration or a Partial Mixed Ration comprising between 0 and 5 wt.% of minerals, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration or a Partial Mixed Ration comprising between 0 and 5 wt.% of trace elements, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration or a Partial Mixed Ration comprising between 0 and 5 wt.% of vitamins, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration or a Partial Mixed Ration comprising between 0 and 5 wt.% of additives, based on the dry weight of the feed composition.

In an embodiment, the feed composition is a Total Mixed Ration or a Partial Mixed Ration, comprising between 0 and 5 wt.% of minerals, trace elements, vitamins and additives, based on the dry weight of the feed composition.

In an embodiment, the roughages are selected from the group consisting of chopped straw, maize silage, grass silage, by-products and combinations thereof. Proper use of good quality roughages reduces the quantity of concentrates needed in rations and provides a plentiful supply of vitamins and minerals.

In an embodiment, the roughages have a particle size distribution, according to the Penn State Particle Separator, such that less than 10 wt.% of the particles have a size of less than 1.18 mm, based on the total weight of the roughages.

In an embodiment, the binder is a flour, a ground material or combinations thereof, preferably selected from the group consisting of wheat flour, corn flour, ground wheat, ground corn and combinations thereof. These materials, preferably after being subjected to gelatinization, increase the adhesiveness of the one or more base feed materials, leading to a feed composition which is more homogeneous and from which it is less difficult for livestock to feed sort.

In an embodiment, the binder has a particle size distribution that is such that more than 50 wt.% of the particles have a size of less than 500 μm, and/or more than 25 wt.% of the particles have a size that is less than 250 μm, and/or more than 15 wt.% of the particles have a size that is less than 150 μm.

In an embodiment, the feed composition comprises between 0.5 and 5 wt.% of the binder, preferably between 1 and 2.5 wt.%, more preferably 2 wt.%, based on the dry weight of the one or more base feed materials. The effect thereof is optimal binding of the feed base material particles. The present inventors have observed that even a content of 0.5 wt.% of the binder in the feed composition, based on the dry weight of the one or more base feed materials, increases the homogeneity and adhesiveness of the one or more base feed materials, which also leads to reduced feed sorting.

In an embodiment, the particle size distribution of the feed composition, according to the Penn State Particle Separator, is such that less than 5 wt.% of particles have a size of less than 1.18 mm, based on the total weight of the feed composition. This also shows that the feed composition has a particle size distribution, according to the Penn State Particle Separator, such that the feed composition comprises less particles having a size < 1.18 mm when compared to the roughages or when compared to a mixed ration to which no binder has been added.

In an embodiment, the particle size distribution of the feed composition, according to the Penn State Particle Separator, is such that at least 40 wt.% of the particles have a size of at least 19 mm, preferably at least 45 wt.% or even 50 wt.%, more preferably at least 55 wt.%, even more preferably at least 65 wt.%, based on the total weight of the feed composition.

Many methods may be used to prepare feed compositions. The present invention also relates in an aspect to a method for the preparation of a feed composition, comprising mixing one or more base feed materials with a binder and optionally water to obtain a feed composition. The one or more base feed materials may comprise one or more components selected from the group consisting of roughages, mash, minerals, trace elements, vitamins, and additives. The binder is for example a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, preferably the starch-based binder is a pre-gelatinized starch-based binder.

The mixing of the one or more base feed materials with the binder, and optionally water, may be carried out in different ways. For example, a first base feed material may be premixed with a second base feed material and subsequently the pre-mixture may be mixed with a binder and optionally one or more minerals and optionally one or more additional base feed materials. Water may be added to the mixture obtained to prepare the feed composition.

For example, a straw (e.g. chopped wheat) may be first mixed with a silage (e.g. maize) to obtain a first mixture. Subsequently mash, a binder and minerals may be added to the first mixture to obtain a second mixture. Finally, water can be added to the second mixture to obtain a Mixed Ration. This Mixed Ration can be a Total Mixed Ration or Partial Mixed Ration, depending if all concentrate is added to the mixture (TMR) or only part of the concentrate is added to the mixture (PMR).

For example, a first base feed material may be premixed with a second base feed material and subsequently the pre-mixture may be mixed with a binder and optionally water, optionally one or more minerals and optionally one or more additional base feed materials.

For example, a first base feed material may be premixed with a binder, optionally water and optionally one or more minerals. This pre-mixture may, optionally after a resting time, be mixed with one or more additional base feed materials.

The mixing of the one or more base feed materials with the binder may be also carried out by firstly mixing mash, the binder, minerals and optionally water to obtain a first mixture. This first mixture may be rested for e.g. 1 hour or more. Then roughages in the form of silage or straw (e.g. chopped wheat) may be added to the first mixture to obtain a second mixture. Finally, grass silage, maize silage and optionally additional water may be added to the second mixture to form a Total Mixed Ration or Partly Mixed Ration. If all concentrate is added to the mixture then a TMR is obtained; on the contrary, if only part of the concentrate is added to the mixture, then a PMR is obtained.

It will be understood that these are two examples and that the person skilled in the art will know how to mix the one or more base feed materials with the binder in order to obtain a Mixed Ration.

In an embodiment, the feed composition obtained comprises between 0.5 and 5 wt.% of the binder, preferably between 1 and 2.5 wt.%, more preferably 2 wt.%, based on the dry weight of the one or more base feed materials.

In an embodiment, water is added in an amount of at least 5 wt.% based on the total weight of the feed composition, preferably at least 15 wt.%, more preferably at least 25 wt.%.

In another aspect the present disclosure relates to the use of a binder in a feed composition for the reduction of feed sorting in livestock, preferably a starch-based binder, a protein-based binder, a pectin-based binder, or a combination of two or more thereof, more preferably the starch-based binder is a pre-gelatinized starch-based binder. The livestock is for example cattle, preferably ruminants, more preferably cows, goats or sheep. Cows may be for instance dairy cows, beef cows and/or young stock.

The binder may be in the form of a flour, a ground material or combinations thereof. For example, the binder may be selected from the group consisting of wheat flour, ground corn, ground wheat and combinations thereof. In an embodiment, the binder is selected from the group of maltodextrin, gelatin, extruded whole corn, extruded corn meal, extruded rice meal and extruded wheat flour.

In an embodiment the binder has a particle size that is such that more than 50 wt.% of the particles have a size of less than 500 μm, and/or more than 25 wt.% of the particles have a size that is less than 250 μm, and/or more than 15 wt.% of the particles have a size that is less than 150 μm.

The binder may have a particle size distribution in which 90% of the particles have a size of < 1000 μm, preferably < 500 μm, more preferably < 250 μm.

The present inventors have observed that by using a binder in a feed composition, feed sorting is also reduced in conditions in which water present in the composition evaporates. With other words, by using a binder in a feed composition according to the present disclosure, when the feed composition is prepared, water is added in a proportion such that the feed composition initially comprises at least 5 wt.% of water based on the total weight of the feed composition. When the feed composition is provided to livestock, water present in the feed composition evaporates, therefore, the water content of the feed composition reduces. However, when a binder is used as described in the present disclosure, this water evaporation or drying of the feed composition does not detrimentally interfere with the reduction of feed sorting.

Furthermore, by using the binder in a feed composition for the reduction of feed sorting in livestock, and in the case in which the livestock are preferably ruminants, rumen health is improved, as every bite taken by the cow, has the same nutritional value.

In another aspect the present disclosure relates to the feed composition according to the invention for use the improvement of ruminant health. The ruminants are preferably cows, goats or sheep.

The embodiments, examples and information regarding the feed composition, the base feed materials and the binder, are applicable to all aspects of the disclosure, meaning the feed composition, the method for the preparation of the feed composition and the use of the binder.

EXAMPLES

The following examples demonstrate the effect of a feed composition and the use of a binder on the reduction of feed sorting.

Base feed materials

Different feed compositions were tested. For all feed compositions roughages were used as one of the one or more base feed materials, comprising chopped grass silage (Chopped G. Sil.), maize silage (Maize Sil.) and chopped wheat straw (Chopped W. S.). Moreover, the feed compositions comprised mash grinded fine (Mash fine), mash grinded coarse (Mash coarse), and minerals as base feed materials. The particle size distribution of the base feed materials, which was measured according to the Penn State Particle Separator, is shown in Table 1.

Table 1. Particle size distribution of base feed materials

Base feed material	Particle size distribution – Fraction wt.%				
	> 19 mm	<19 mm > 8 mm	< 8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
Chopped G. Sil.	86.5	9.8	3.1	0.6	0.0
Maize Sil.	9.0	66.6	17.9	6.4	0.0
Chopped W. S.	23.1	33.3	24.1	12.1	7.4
Mash fine	00.7	00.7	0.0	36.4	62.3
Mash coarse	00.0	00.2	7.8	49.4	42.6
Minerals	0	0	0	0	100

Binders

Different binders such as maltodextrin, gelatin, extruded whole corn, extruded corn meal, extruded rice meal and extruded wheat flour were used. The particle size distribution of the binders was determined according to airstream sieving (sieving using an airstream from below the sieve, through the sieve), and this is shown in Table 2. Sieve mesh sizes of 106μm, 150μm, 250μm, 500μm, and 1000μm have been used.

Table 2. Particle size distribution of binders

Binder	Particle size distribution – Fraction wt.%				
	<1000μm	<500μm	<250μm	<150μm	<106μm
Maltodextrin	99.8	99.8	87.9	68.3	56.1
Gelatin	99.9	99.9	99.4	98.5	97.0
Extruded whole corn	98.8	85.9	60.6	35.3	21.9
Extruded corn meal	100	98.1	91.1	75.9	55.9
Extruded rice meal	100	100	99.0	97.9	88.8
Extruded wheat flour	100	100	99.7	93.3	69.4

Feed compositions

Feed compositions were prepared following the Total Mixed Ration (TMR) method.

The procedure followed for preparing the feed compositions was the following:

Structured chopped wheat straw was mixed with maize silage. Subsequently, mash, minerals and optionally the binder were added to the previous mixture. Optionally, water was added. Finally, grass silage was added to the mixture to prepare the feed composition, both according to the present disclosure and not according to the present disclosure.

When considering only the base feed materials; i.e. chopped wheat straw, maize silage, mash, minerals and grass silage; three Total Mixed Rations or compositions were prepared.

TMR1: TMR for lactating cow ration comprising fine grinded mash. TMR 1 contains 4 kg dry matter (DM) grass silage, 3.99 kg DM of maize silage, 0.17 kg DM of straw chopped, 1.22 kg DM of fine grinded mash, and 0.15 kg DM of minerals. In TMR1 the mash was grinded with a hammer-mill.

TMR2: TMR for lactating cow ration with coarse grinded mash. TMR 2 contains 4 kg dry matter (DM) of grass silage, 3.99 kg DM of maize silage, 0.17 kg DM of straw chopped, 1.22 kg DM of coarse grinded mash, and 0.15 kg DM of minerals. In TMR2 the mash was grinded with a roller-mill.

TMR 3: TMR for dry (non-lactating) cow ration with coarse grinded mash. TMR 3 contains 3.50 kg dry matter (DM) of grass silage, 3.51 kg DM of maize silage, 3.53 kg DM of straw chopped, 1.53 kg DM of coarse grinded mash, and 0.10 kg DM of minerals. In TMR3 the mash was grinded with a roller-mill.

The particle size distribution of the rations was determined according to Penn State Particle Separator, and this is shown in Table 3.

Table 3. Measured particle size distribution of TMR.

CE	Total mix. ration	% Dry matter	Particle size distribution – Fraction wt.%				
			> 19 mm	<19 mm > 8mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
c.1	TMR1	45.5	63.4	15.9	7.0	10.9	2.9
c.2	TMR2	45.4	62.7	17.2	8.3	9.2	2.7
c.3	TMR3	53.2	55.8	19.8	10.3	10.5	3.6

From table 3 it can be see that small particles (<1.2 mm) do segregate within a TMR according to the use of the Penn State Particle Separator. These Total Mixed Rations can be seen as composition comprising only base feed materials and to which no water has been added.

Effect of water without binder

Water was added to the base feed materials with the mash and minerals. The amount of added water was determined based on the target amount of dry matter of the final feed composition. The results regarding the effect of adding water to the base feed materials is shown in Table 4 and compared with the results of Table 3. The amount of water (wt. % water) is based on the total weight of the feed composition.

Table 4. Effect of adding water

CE	Total mix. Ration	wt. % Dry matter	wt. % Water	Particle size distribution – Fraction wt.%				
				> 19 mm	<19 mm > 8mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
c.4	TMR1	39.0	14	64.8	20.3	7.1	7.3	0.5
c.5	TMR2	39.0	14	61.9	22.1	9.3	6.5	0.2
c.6	TMR3	45.2	15	51.1	23.3	12.6	10.7	2.3

From table 4 it can be seen that by adding water, the wt.% of fraction < 1.18 mm is reduced, as shown in comparative examples (CE) 4-6 as compared with the TMR of CE 1-3 to which no water has been added. This means that adding water has a positive effect on the reduction of particle segregation.

Effect over time of water and of water in combination with a binder

To show the effect over time of adding water, the particle size distribution of Total Mixed Rations was measured right after adding water to the samples and after 24 hours. This is shown in Table 5, in which examples with an asterisk (*) refer to samples for which the particle size distribution of the TMR was measured after 24 hours.

The present inventors have observed that adding water has a positive effect on reduction of particle segregation; however, particles fall apart again when water is evaporated or diffused into the feed materials over time. This is demonstrated as the wt.% of particles having a size > 19 mm decreases and the wt.% of particles having a size < 1.18 mm increases with time, as can be seen in Table 5. The amount of water (wt. % water) is based on the total weight of the feed composition.

Table 5. Particle size distribution of TMR with added water.

CE	Total mix. ration	% Dry matter	wt. % Water	Particle size distribution – Fraction wt.%				
				> 19 mm	<19 mm > 8mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
c.7	TMR1	39.0	14	73.6	11.6	5.4	7.6	1.8
c.7*	TMR1	39.0	14	63.2	15.6	7.3	10.6	3.3
c.8	TMR2	39.0	14	69.0	14.2	6.9	8.0	1.8
c.8*	TMR2	39.0	14	63.7	16.0	7.9	9.7	2.7
c.9	TMR3	45.2	15	65.2	13.2	8.7	9.5	3.4
c.9*	TMR3	45.2	15	60.2	15.4	10.3	10.7	3.5

In addition, the particle size distribution of Total Mixed Rations was measured for composition to which both water and a binder were added. This in order to show the effect of adding water and a binder to the TMRs. The binder used in all examples of Table 6 is extruded whole corn; more information regarding this binder can be seen in Table 2. These results are presented in table 6, in which examples with an asterisk (*) refer to samples for which the particle size distribution of the TMR was measured after 24 hours. The amount of water (wt. % water) is based on the total weight of the feed composition and the amount of binder (wt. % bin) is based on the dry weight of the one or more base feed materials.

Table 6. Particle size distribution of TMR with water and a binder

E	Total mix. ration	% Dry matter	wt. % water	wt. % bin	Particle size distribution – Fraction wt.%				
					> 19 mm	<19 mm > 8 mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
10	TMR1	39.0	14	2	71.2	13.2	6.1	7.8	2.0
10*	TMR1	39.0	14	2	64.6	16.4	7.0	9.1	2.8
11	TMR2	39.0	14	2	71.7	12.9	7.1	6.9	1.4
11*	TMR2	39.0	14	2	71.9	12.3	6.8	7.2	1.8
12	TMR3	45.2	15	2	72.8	9.7	7.6	7.9	2.1
12*	TMR3	45.2	15	2	76.5	6.9	7.1	7.3	2.3

By adding a binder in combination with water to the TMR the particle size distribution of the compositions shows a smaller variation over time when compared to the compositions to which only water has been added.

Effect of adding different type of binders

Different binders and water were added to the TMRs. The effect is shown in table 7. Data from tables 3 (CE 1, 2 and 3) and 4 (CE 4, 5 and 6) have been repeated in this table to provide a more complete overview. The amount of water (wt. % water) is based on the total weight of the feed composition and the amount of binder (wt.% bin) is based on the dry weight of the one or more base feed materials.

From the results in table 7 can be conclude that most used binders had a positive effect on reducing particle segregation of TMR by reducing the amount of fine particles (<1.18mm) and increasing the amount of coarse particles (>19mm) in comparison to Comparative Examples wherein no water and no binder is added, as well as in comparison to wherein water was added but no binder.

Effect of dose-response binder addition

To see if the binder effect is dose-dependent a dose-response experiment was performed. Binder used in this experiment was a starch-based binder (extruded corn meal). The binder was added in a proportion between 0 and 4 wt.% based on the dry weight of the one or more base feed materials; the amount of added binder (wt.% bin.) and the effect on the particle size distribution of the TMRs is shown in table 8. It should be noted that water was also added to the different formulations, in an amount of 14 wt.% for TMR 1 and TMR 2 and 15 wt.% for TMR 3 based on the total weight of the composition.

Table 7. Particle size distribution of TMR with water and a binder. Effect of different binders

(C)E	Total mix. ration	Binder	wt. % water	wt. % bin	Particle size distribution – Fraction wt.%				
					> 19 mm	<19 mm > 8mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
1 (CE)	TMR1	-	-	-	63.4	15.9	7.0	10.9	2.9
4 (CE)	TMR1	-	14	-	64.8	20.3	7.1	7.3	0.5
13	TMR1	Maltodextrin	14	2	67.9	20.0	6.7	5.5	0.0
14	TMR1	Gelatin	14	2	74.8	14.9	5.7	4.6	0.0
15	TMR1	Extruded Whole Corn	14	2	72.5	14.1	6.1	6.8	0.5
16	TMR1	Extruded Corn Meal	14	2	68.3	14.9	7.4	8.2	1.3
17	TMR1	Extruded Rice Meal	14	2	71.4	13.7	6.8	7.3	0.8
2 (CE)	TMR2	-	-	-	62.7	17.2	8.3	9.2	2.7
5 (CE)	TMR2	-	14	-	61.9	22.1	9.3	6.5	0.2
18	TMR2	Maltodextrin	14	2	65.1	22.2	8.1	4.6	0.0
19	TMR2	Gelatin	14	2	77.0	10.9	6.2	5.4	0.5
20	TMR2	Extruded whole corn	14	2	72.9	16.3	6.7	4.1	0.0
21	TMR2	Extruded Corn Meal	14	2	74.9	11.9	6.5	5.9	0.9
22	TMR2	Extruded Rice Meal	14	2	69.5	16.4	7.3	6.3	0.5
23	TMR2	Extruded Wheat Flour	14	2	78.5	7.9	7.3	5.6	0.6
3 (CE)	TMR3	-	-	-	55.8	19.8	10.3	10.5	3.6
6 (CE)	TMR3	-	15	-	51.1	23.3	12.6	10.7	2.3
24	TMR3	Maltodextrin	15	2	61.5	17.5	9.9	8.9	2.3
25	TMR3	Gelatin	15	2	63.4	17.8	10.3	7.8	0.7
26	TMR3	Extruded Whole Corn	15	2	61.4	17.4	10.3	9.2	1.7
27	TMR3	Extruded Corn Meal	15	2	69.5	12.5	8.2	8.1	1.7
28	TMR2	Extruded Rice Meal	15	2	69.4	12.5	9.0	7.7	1.3

Table 8. Effect of dose-response binder addition on the particle size distribution of TMR.

(C)E	wt.% Bin.	Total mix. ration	% Dry matter	Particle size distribution – Fraction wt.%				
				> 19 mm	<19 mm > 8mm	<8 mm > 4 mm	<4 mm > 1.18 mm	<1.18 mm (Bottom)
29 (CE)	0	TMR1	39	73.6	11.6	5.4	7.6	1.8
30	1	TMR1	39	70.3	14.3	6.0	8.2	1.3
31	2	TMR1	39	68.3	14.9	7.4	8.2	1.3
32	3	TMR1	39	71.5	14.3	6.2	7.2	0.7
33	4	TMR1	39	77.3	11.2	5.6	5.4	0.5
34 (CE)	0	TMR2	39	69.0	14.2	6.9	8.0	1.8
35	1	TMR2	39	68.2	15.7	7.3	7.6	1.2
36	2	TMR2	39	74.9	11.9	6.5	5.9	0.9
37	3	TMR2	39	74.7	14.0	5.8	5.3	0.1
38	4	TMR2	39	81.0	10.7	4.7	3.4	0.2
39 (CE)	0	TMR3	45.2	65.2	13.2	8.7	9.5	3.4
40	1	TMR3	45.2	62.2	15.3	9.6	10.1	2.7
41	2	TMR3	45.2	69.5	12.5	8.2	8.1	1.7
42	3	TMR3	45.2	77.3	7.9	6.8	7.2	0.8
43	4	TMR3	45.2	67.2	14.1	9.3	8.0	1.4

From table 8 it can be seen that the amount of added binder to the TMR has an effect on the segregation of small particles. This binder-effect is dose response dependent. In this sense, it can be observed that by increasing the amount of added binder to the TMR, the fraction of particles having a particle size < 1.18 mm is reduced.

<u>Improvement of the nutritional homogeneity between sequential bites of the cow after addition of a binder to the mixed ration.</u>

In order to shown the improvement of the nutritional homogeneity between sequential bites of a feed composition for cows after addition of a binder to a mixed ration, a mixed ration without treatment (con.) and a mixed ration to which a binder were added (treat.) were compared. The total mixed ration, considering only the feed materials, contains 1.45 kg dry matter (DM) of soybean meal, 2.86 kg of maize meal, 3.60 kg DM of wheat meal, 0.53 DM kg of vitamins and minerals, 1.55 kg DM brewers grain, 12.7 kg DM of grass silage, and 2.72 kg DM of maize silage. To this mixture was 25.6 kg water added.

The amounts of binder that were added to a treated mixed ration in order to show the effect of adding a binder on the nutritional composition of the mixed ration was 0.4 kg. These results are shown in table 9.

Table 9. Effect of adding a binder on the nutritional composition of the separated fractions by the PSPS method of mixed ration on farm by determination of starch, crude protein, calcium- and copper content of fraction.

	Starch (%)		Crude protein (%)		Calcium (%)		Copper (%)	
Separated fraction	Con.	Treat.	Con.	Treat.	Con.	Treat.	Con.	Treat.
TMR >19mm	51,9	69,3	58,0	70,8	57,2	70,9	59,3	71,7
TMR >4<19mm	37,1	26,3	33,3	25,6	33,6	26,1	33,1	24,7
TMR <4mm	11,0	4,3	8,6	3,6	9,3	3,0	7,5	3,7

From the results in the table above it can be concluded that concentrate (starch and crude protein) and premix (Ca and Cu) particles adhere both better to roughage particles when a binder is added to the mixed ration. This implicates that every bite of a cow ingesting the mixed ration with added binder is more likely to be nutritionally the same than when no binder is added. When every bite is more nutritionally the same, less disturbances in the gastro intestinal tract are expected.

<u>Effect of adding a binder to mixed ration on sorting behavior, body condition, manure consistency, rumen fill score and rumination of cows</u>

The effect of adding a binder to a mixed ration on sorting behavior, body condition, manure consistency, rumen fill score and rumination of cows is shown by using the mixed ration shown in the effect previously discussed (improvement of the nutritional homogeneity) and which results are shown in Table 9.

Table 10. Effect of adding binder (Treatment) to the a mixed ration, after 3 weeks, on feed sorting behavior, body condition, manure consistency, rumen fill score and rumination score of cows in a commercial herd in the Netherlands.

	Control	Treatment
Feed sorting behaviour score (scale 1-10)	8	9
Body condition score (scale 1-5)	2,8 (± 0,88)	2,8 (± 0,54)
Manure consistency score (scale 1-5)	3,2 (± 1,08)	2,9 (± 0,54)
Rumen fill score (scale 1-5)	3,6 (± 1,09)	3,4 (± 0,53)
Rumination score (# of mastications between two ructi)	66	67

In table 10, the variance is mentioned between brackets. From the results shown on table 10, it can be concluded that cows fed the mixed ration with a binder repeatedly show less feed sorting behavior, show less variation in body condition, manure consistency and rumen fill (score) between cows in the commercial herd. This indicates that cows are less able to select specific feed particles, resulting in more equal (nutritional) feed intake (within and) between cows resulting in more uniform manure consistency, body condition and rumen fill.

Effect of adding a binder to mixed ration on feed/nutrient efficacy in cows

The effect of adding a binder to mixed ration on feed/nutrient efficacy in cows was determined by comparing total daily fat and protein corrected milk production with respect to the total daily feed intake on dry matter basis for periods in which a mixed ration was fed to the cows without a binder (control) and periods in which a mixed ration, to which a binder was added to the mixed ration (treatment), was fed to the cows. The mixed rations for Farm 1 correspond to the same shown in the effects previously discussed, and which results are shown in table 9 and table 10. Farms 2, and 3 used mixed rations which are largely comparable to those of Farm 1. The feed efficiencies in table 11 are each an average of the last week (7 days) of a period in which a specific mixed ration was fed to the cows.

Table 11. Effect of adding a binder on the feed efficiency in 3 Dutch commercial dairy herds.

Feed efficiency	Control	Treatment
Farm 1	1.61	1.62
Farm 2	1.41	1.54
Farm 3	1.36	1.40

From the results shown on table 11, it can be concluded that commercial herds fed a mixed ration with a binder lead to a significant increase in feed efficiency, meaning that more kilograms of milk are produced by kilogram of feed composition or mixed ration. For farms 2 and 3, the feed efficiency has increased more than for farm 1. This can be explained by the fact that farm 1 used more high quality feed, leading already to a high feed efficiency for the control experiment. When feed efficiency was increased, specific nutrient efficiencies such as N- and P-efficiency were also increased.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. Any reference signs in the claims should not be construed as limiting the scope thereof.

The foregoing description provides embodiments of the invention by way of example only. The scope of the present invention is defined by the appended claims. One or more of the objects of the invention are achieved by the appended claims.

CONCLUSIES

1. Voersamenstelling omvattende een of meer basisvoermaterialen en een binder, waarin de voersamenstelling bij voorkeur een compleet gemengd rantsoen (total mixed ration) of een gedeeltelijk gemengd rantsoen (partial mixed ration) is.

2. Voersamenstelling volgens conclusie 1, waarin de compositie verder water omvat, bij voorkeur in een hoeveelheid van ten minste 5 gew.% gebaseerd op het totaalgewicht van de voersamenstelling, meer bij voorkeur ten minste 15 gew.%, meer bij voorkeur ten minste 25 gew.%.

3. Voersamenstelling volgens conclusie 1 of 2, waarin de binder een zetmeel-gebaseerde binder, een eiwit-gebaseerde binder, een pectine-gebaseerde binder, of een combinatie van twee of meer daarvan is, bij voorkeur is de zetmeel-gebaseerde binder een pre-gegelatineerde zetmeel-gebaseerde binder.

4. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de een of meer basisvoermaterialen een of meer componenten omvat geselecteerd uit de groep van ruwvoer, meel (“mash”), mineralen, sporenelementen, vitaminen en additieven.

5. Voersamenstelling volgens conclusie 4, waarin het ruwvoer is geselecteerd uit de groep van gehakseld stro, maiskuilvoer, graskuilvoer, bijproducten en combinaties daarvan.

6. Voersamenstelling volgens conclusie 4 en 5, waarin het ruwvoer een deeltjesgrootteverdeling, volgens de Penn State Particle Separator, heeft, zodanig dat minder dan 10 gew.% van de deeltjes een grootte hebben van minder dan 1,18 mm, gebaseerd op het totaalgewicht van het ruwvoer.

7. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de binder een meel, een gemalen materiaal of een combinatie daarvan is, bij voorkeur geselecteerd uit de groep bestaande uit tarwemeel, maismeel, gemalen tarwe, gemalen mais en combinaties daarvan.

8. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de binder een deeltjesgrootteverdeling heeft, zodanig dat meer dan 50 gew.% van de deeltjes een grootte van minder dan 500 µm heeft, en/of meer dan 25 gew.% van de deeltjes een grootte van minder dan 250 µm heeft, en/of meer dan 15 gew.% van de deeltjes een grootte van minder dan 150 µm heeft.

9. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de samenstelling tussen 0,5 en 5 gew.% van de binder omvat, bij voorkeur tussen 1 en 2.5 gew.%, meer bij voorkeur 2 gew.%, gebaseerd op het droog gewicht van de een of meer basisvoermateriaal.

10. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de deeltjesgrootteverdeling van de voersamenstelling, volgens de Penn State Particle Separator, zodanig is dat minder dan 20 gew.%, bij voorkeur minder dan 5 gew.% van de deeltjes een grootte van minder 1.18 mm heeft, gebaseerd op het totaalgewicht van de voersamenstelling.

11. Voersamenstelling volgens een of meer van de voorgaande conclusies, waarin de deeltjesgrootteverdeling van de voersamenstelling, volgens de Penn State Particle Separator, zodanig is dat ten minste 10 gew.% van de deeltjes een grootte van ten minste 19 mm heeft, bij voorkeur ten minste 25 gew.% of zelfs 40 gew.%, bij voorkeur ten minste 45 gew.% of zelfs 50 gew.%, meer bij voorkeur ten minste 55 gew.%, nog meer bij voorkeur ten minste 65 gew.%, gebaseerd op het totaalgewicht van de voersamenstelling.

12. Werkwijze voor het bereiden van een voersamenstelling, omvattende het mengen van een of meer basisvoermaterialen met een binder en optioneel water om een voersamenstelling te verkrijgen, waarin bij voorkeur de een of meer basismaterialen een of meer componenten omvat geselecteerd uit de groep bestaande uit ruwvoer, meel, korrelvormig meel, mineralen, sporenelementen, vitaminen en additieven; waarin bij voorkeur de binder een zetmeel-gebaseerde binder, een eiwit-gebaseerde binder, een pectine-gebaseerde binder, of een combinatie van twee of meer daarvan is, bij voorkeur is de zetmeel-gebaseerde binder een pre-gegelatineerde zetmeel-gebaseerde binder.

13. Werkwijze volgens conclusie 12, waarin de verkregen voersamenstelling tussen 0,5 en 5 gew.% omvat van de binder, bij voorkeur tussen 1 en 2,5 gew.%, meer bij voorkeur 2 gew.%, gebaseerd op het droog gewicht van de een of meer basismaterialen.

14. Gebruik van een binder in een voersamenstelling voor de reductie van voersortering in vee, bij voorkeur een zetmeel-gebaseerde binder, een eiwit-gebaseerde binder, een pectine-gebaseerde binder, of een combinatie van twee of meer daarvan, bij voorkeur is de zetmeel-gebaseerde binder een pre-gegelatineerde zetmeel-gebaseerde binder.

15. Gebruik van een binder volgens conclusie 14, waarin de binder in de vorm is van een meel, een gemalen materiaal of combinaties daarvan, bij voorkeur geselecteerd

uit de groep bestaande uit tarwemeel, gemalen mais, gemalen tarwe en combinaties daarvan.

16. Gebruik van een binder volgens conclusie 14 of 15, waarin de binder een deeltjesgrootteverdeling heeft, zodanig dat meer dan 50 gew.% van de deeltjes een grootte van minder dan 500 µm heeft, en/of meer dan 25 gew.% van de deeltjes een grootte van minder dan 250 µm heeft, en/of meer dan 15 gew.% van de deeltjes een grootte van minder dan 150 µm heeft.

17. Gebruik van een binder volgens een van de conclusies 14-16, waarin het vee rundvee is, bij voorkeur herkauwers, meer bij voorkeur koeien, geiten of schapen.

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	75470NL
Nederlands aanvraag nr. **2023112**	Indieningsdatum **10-05-2019**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Agrifirm Group B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **20-07-2019**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN74143**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

Zie onderzoeksrapport

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**Zie onderzoeksrapport**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2023112

A. CLASSIFICATIE VAN HET ONDERWERP
INV. A23K40/10 A23K10/30 A23K50/10
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
A23K

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, BIOSIS, FSTA, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X,D	MILLER-CUSHON E K ET AL: "Feed sorting in dairy cattle: Causes, consequences, and management", JOURNAL OF DAIRY SCIENCE, deel 100, nr. 5, 2017, bladzijden 4172-4183, XP029980100, ISSN: 0022-0302, DOI: 10.3168/JDS.2016-11983 in de aanvraag genoemd * het gehele document * -----	1-17

-/--

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
6 februari 2020	
Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Heirbaut, Marc

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ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2023112

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	L J Gordon ET AL: "Technical note: Impact of a molasses-based liquid feed supplement on the feed sorting behavior and growth of grain-fed veal calves 1", Journal of Animal Science, 1 augustus 2016 (2016-08-01), bladzijde 3519, XP055665106, Champaign DOI: 10.2527/jas2015-0195 Gevonden op het Internet: URL:https://academic.oup.com/jas/article-abstract/94/8/3519/4791556?redirectedFrom=fulltext [gevonden op 2020-02-04] * samenvatting * * bladzijde 3520, kolom 1, alinea 2 * * bladzijde 3522, kolom 2, laatste alinea * * bladzijde 3525, kolom 1, alinea 2 * -----	1-17
X	CA 2 778 696 A1 (SUPREME PETFOODS LTD [GB]) 30 november 2013 (2013-11-30) * bladzijde 7, regels 8-14 * * bladzijde 9, regels 9-13 * * bladzijde 10, regels 19-22 * * bladzijde 17, regels 1-30 * * conclusies 1-7,10,12-18 * -----	1-17
X	US 3 420 671 A (HESS EARL H ET AL) 7 januari 1969 (1969-01-07) * het gehele document * -----	1-17
A	US 4 584 024 A (HISADA YOJI [US] ET AL) 22 april 1986 (1986-04-22) * het gehele document * -----	1-17
A,D	US 3 565 651 A (WAGGLE DOYLE H) 23 februari 1971 (1971-02-23) in de aanvraag genoemd * het gehele document * -----	1-17

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ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2023112

In het rapport genoemd octrooigeschrift		Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
CA 2778696	A1	30-11-2013	GEEN		
US 3420671	A	07-01-1969	GEEN		
US 4584024	A	22-04-1986	JP S60118150	A	25-06-1985
			US 4584024	A	22-04-1986
US 3565651	A	23-02-1971	GEEN		

WRITTEN OPINION

File No. SN74143	Filing date *(day/month/year)* 10.05.2019	Priority date *(day/month/year)*	Application No. NL2023112
International Patent Classification (IPC) INV. A23K40/10 A23K10/30 A23K50/10			
Applicant Agrifirm Group B.V.			

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner Heirbaut, Marc

WRITTEN OPINION

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	6, 10, 11, 16
	No:	Claims	1-5, 7-9, 12-15, 17
Inventive step	Yes:	Claims	
	No:	Claims	1-17
Industrial applicability	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations

   see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

Item V

1 Cited prior art documents

Reference is made to the following prior art (D):

D1	MILLER-CUSHON E K ET AL: "Feed sorting in dairy cattle: Causes, consequences, and management", JOURNAL OF DAIRY SCIENCE, vol. 100, nr. 5, 2017, bladzijden 4172-4183, XP029980100
D2	L J Gordon ET AL: "Technical note: Impact of a molasses-based liquid feed supplement on the feed sorting behavior and growth of grain-fed veal calves", Journal of Animal Science, 1 augustus 2016 (2016-08-01), bladzijde 3519, XP055665106
D3	CA 2 778 696 A1 (SUPREME PETFOODS LTD [GB]) 30 november 2013 (2013-11-30)
D4	US 3 420 671 A (HESS EARL H ET AL) 7 januari 1969 (1969-01-07)
D5	US 4 584 024 A (HISADA YOJI [US] ET AL) 22 april 1986 (1986-04-22)

Particular reference is made to the passages and the combination of features taught therein as indicated in the search report.

All of this prior art was published before the effective date of the present application.

2 Novelty

2.1 Observations with regard to claim interpretation

The following observations with regard to claim interpretation are relevant for the examination of novelty:

(i) The term "binder" employed in the present claims is a functional feature. Consequently, the disclosure of the use of a compound which is suitable for use as a binder anticipates this feature.

(ii) The feature "wherein the composition further comprises water" in present claim 2 has not distinguishing value, as any feed composition inherently comprises a certain amount of water.

(iii) The feature "the binder is (...) a ground material" in present claims 7, 15 is not limited to ground <u>flour</u> materials.

(iv) The term "by-products" in present claim 5 is vague, and cannot be employed to establish novelty over a prior art document in which said term is not used. It is not set out from which type of product the by-products are derived.

2.2 Document D1

Document **D1** is a study of the phenomenon of feed sorting by (dairy) cattle and discusses factors, implications and control. It discloses (see in particular the specific passages indicated in the search report) that in mature cows and young calves, feed sorting is influenced by forage inclusion rate, particle size, and dry matter content. Ruminants are capable of selectively consuming certain portions of plants and this ability extends to the consumption of a total mixed ration (TMR). Sorting behaviour is typically against longer forage particles and in favour of smaller particles. Sorting of a TMR can mean that the ration cows actually consume is much higher in fermentable carbohydrates than intended, and much lower in effective fibre. This, in turn, may increase the risk of depressed rumen pH and SARA. In support of that hypothesis, cited literature demonstrated associations between sorting and various measures of rumen pH. For example, an association was noted between sorting of long ration particles, *i.e.* particles >19 mm screen of the Penn State Particle Separator (PSPS) and maximum rumen pH: those cows selecting most against long particles had the lowest maximum rumen pH. The same authors also reported that increased sorting for particle fractions that were higher in starch and lower in NDF was associated with reduced ruminal pH variables. Feed sorting is greatly subject to ration characteristics, including forage inclusion rate, particle size, and dry matter (DM) content. Altering ration DM content has been explored in several studies as a potential means of reducing feed sorting, based on the assumption that water addition will help bind small particles to large particles, making it more difficult for cows to consume selectively. Researchers added water to a dry TMR to reduce dietary DM from 80.8 to 64.4% and found that water addition reduced sorting against long particles and tended to result in increased NDF intake and greater milk fat percentage (3.31 *vs.* 3.41%). Similarly, adding water to a TMR to reduce dietary DM from 62 to 52% resulted in less sorting for the smallest ration particles.

It is pointed out that water is suitable for use as a binder in the sense of the present application, and is explicitly described to have this functionality in document **D1**.

Consequently, independent claims 1, 12, 14 and dependent claims 2-5, 17 lack novelty with regard to document **D1**.

2.3 Document D2

Document **D2** is a study (see in particular the specific passages indicated in the search report) designed to determine the effect of adding a molasses-based liquid feed (LF) supplement to a high-grain mixed ration on the feed sorting behavior and growth of grain-fed veal calves. Twenty-four Holstein bull veal calves (90.2 ± 2.6 d of age, weighing 137.5 ± 16.9 kg) were split into groups of 4 and exposed, in a crossover design with 35-d periods, to each of 2 treatment diets: 1) control diet (76.0% high-moisture corn, 19.0% protein supplement, and 5.0% alfalfa/grass haylage) and 2) LF diet (68.4% corn, 17.1% protein supplement, 9.0% molasses-based LF, and 4.5% alfalfa/grass haylage). Feed samples of fresh feed and refusals were collected 3 times/wk for particle size analysis. The particle size separator had 3 screens (19, 8, and 1.18 mm) and a bottom pan, resulting in 4 fractions (long, medium, short, and fine). The results suggest that supplementation of a molasses-based LF to high-grain fattening veal calf diets can reduce variability in feed consumption, both within and across days. Literature stating that molasses-based liquid feed (LF) supplements have been shown to reduce feed sorting and promote greater intake and milk production in dairy cows is cited.

Consequently, independent claims 1, 12, 14 and dependent claims 2-5, 17 lack novelty with regard to document **D2**.

2.4 Document D3

Document **D3** discloses (see in particular the specific passages indicated in the search report) a mono-component animal feed comprising forage material, wherein said forage material is present in particle sizes wherein more than about 20 % of said particle sizes are longer than about 1 mm, which further comprises a binder in order to assist in binding the constituents of the mono-component feed, wherein said binder is preferably present in an amount of between about 1 % and about 5 % of total weight of product, preferably is xanthan gum or konjac mannan, starch (modified or unmodified), tara, cassia, locust bean or guar gum, gelatin or wheat flour. Preferably, between 50-80 % of the fibre lengths exceed 2 mm. There may be a proportion of fibre particles over 15 mm in length.

Consequently, independent claims 1, 12, 14 and dependent claims 2-5, 7-9, 13, 15, 17 lack novelty with regard to document **D3**.

2.5 Document D4

Document **D4** discloses (see in particular the specific passages indicated in the search report) a process for the production of compressed animal feed products which comprises compressing a mixture of subdivided forage material, such as crushed grain, with an edible binder to produce a compact feed product, the improvement which comprises preparing said binder by subjecting a starchy material to an enzyme treatment in the presence of water and an enzyme having the property of hydrolysing said starchy material and a cooking treatment at elevated temperatures and pressures to produce a product having binding properties, mixing said product with said subdivided forage material, and compressing the resulting mixture to produce said compressed animal feed product. The amount of the hydrolytic product to be mixed with the chopped alfalfa or other forage material or animal feed generally varies from about 1% to 5% by weight, preferably about 1% to about 3 % on a dry basis, depending on the type of binder and other factors.

Consequently, independent claims 1, 12, 14 and dependent claims 2-5, 7, 9, 13, 15, 17 lack novelty with regard to document **D4**.

3 Inventive step

3.1 Documents relevant for inventive step assessment

Concerning the question whether the subject-matter of the present application meets the requirements of inventive step, it is stressed that cited documents **D1** to **D4** pertain to the general technical problem of the present application, *i.e.* to provide animal feed, in particular cattle feed, with reduced feed sorting issues, by employing a binder. Consequently, the skilled person seeking to solve this technical problem at the effective date of the present application would have consulted their teachings.

Reference is made to the discussion of their disclosure in paragraph 2 *supra*.

No unexpected technical effects or advantages of the novel dependent claims, on which an inventive step could be based, have been demonstrated in the present application, by means of filing of comparative experimental data wherein the only difference with the reference is the distinguishing feature(s).

Consequently, these features were merely specimens of a range of straightforward known possibilities from which the skilled person would have selected, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.

Furthermore, document **D5** discloses (see in particular the specific passages indicated in the search report) a process for producing pregelatinised potato starch for use as a binder in feed for fish, which comprises carrying out the following steps in order: (a) measuring electrical conductivity of a potato starch slurry having an initial conductivity greater than or equal to 10 µm/cm; (b) adjusting the electrical conductivity of the potato starch slurry to a value between 10 and 300 µm/cm; and (c) thermally gelatinising and dehydrating the potato starch slurry. Consequently, the use of pregelatinised as a binder in animal feed was known at the effective date of the present application, and no inventive step can be based on this feature in the absence of unexpected technical effects provided thereby.

3.2 Certain claimed embodiments do not solve the technical problem

Furthermore, it is pointed out that the present description demonstrates that certain claimed embodiments do not solve the underlying technical problem. The passage on page 19, lines 10-14 specifies that *"most used binders had a positive effect on reducing particle segregation of TMR by reducing the amount of fine particles (< 1.18 mm) and increasing the amount of coarse particles (> 19 mm) in comparison to comparative examples wherein no water and no binder is added, as well as in comparison to wherein water was added but no binder".* The use of the wording "most" suggests that certain binders do not provide the particle segregation reducing effect. Indeed, table 7 demonstrates that extruded whole corn (E15), extruded corn meal (E16, E21) and extruded rice meal (E17, E22) and extruded wheat flour (E23) as well as gelatin (E19) and maltodextrin (E24) do not yield any improvement with regard to the references with 14 *viz.* 15 weight% water without binder (CE4, CE5, CE6).

Consequently, it appears that inventive step has to be denied for this reason as well.

4 Industrial applicability

The present application meets the requirements of industrial applicability, as it can be applied in the animal feed industry.

Item VII

The following objections related to formal issues are raised:

The relevant background art disclosed in documents **D2** to **D5** has not been mentioned in the description, nor have these documents been identified therein.

Item VIII

The present application does not meet the requirements of clarity.

1 Present claim 17 stipulates that the livestock is cattle, preferably ruminants. However, all cattle ("rundvee") are ruminants. The wording of the preferred embodiment of this claim suggests that cattle which are not ruminants exist. Lack of clarity results therefrom.

2 The subject-matter of present claims 6, 10-11 is only characterised by the result to be achieved, *i.e.* to have a small fraction of particles with a diameter of less than 1.18 mm or a large fraction of particles with a diameter of at least 19 mm, which is not allowable, as it only amounts to claiming the underlying technical problem without reciting the essential technical features required for its solution. Lack of clarity results therefrom.

3 Present claims 6, 11 are characterised by a parameter, *i.e.* Penn State Particle Separator, but the measurement method of this parameter is not indicated therein, and the description of this measurement method, as indicated on page 5, paragraph 1, has not been referred to. Lack of clarity results therefrom.

4 The vague and imprecise statement in the description on page 24, lines 18-23 implies that the subject-matter for which protection is sought may be different from that defined by the claims, thereby resulting in lack of clarity when used to interpret them.