(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 August 2016 (11.08.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/126234 A1

(51) International Patent Classification:
A23K 1/00 (2006.01) *A23K 1/18* (2006.01)
A23K 1/16 (2006.01)

(21) International Application Number:
PCT/US2015/014116

(22) International Filing Date:
2 February 2015 (02.02.2015)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: METHOD FOR MAKING ANIMAL FEED

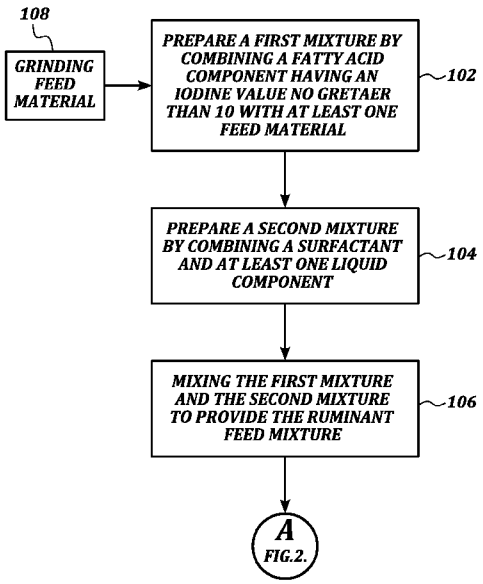

FIG. 1

(57) Abstract: A method of preparing a ruminant feed mixture includes preparing a first mixture by combining a fatty acid component having an Iodine Value no greater than 10 with at least one feed material, preparing a second mixture by combining a surfactant and at least one liquid component, and mixing the first mixture and the second mixture to provide the ruminant feed mixture. The ruminant feed mixture is used in making dietary compositions for ingestion by ruminants. Ingestion of the ruminant feed mixture by a ruminant may increase the milk production or the milk fat content or both of milk produced by the ruminant.

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METHOD FOR MAKING ANIMAL FEED

BACKGROUND

Increasing production and fat content of milk obtained from lactating ruminants have been major goals for dairy farmers. Additional milk production per ruminant is beneficial because it results in a higher yield, thereby increasing profits. Increased milk fat is desirable because it has a higher economic value and can be used in highly desirable food products, such as cheese, yogurt, and the like.

SUMMARY

In some embodiments, a method of preparing a ruminant feed mixture includes preparing a first mixture by combining a fatty acid component having an Iodine Value no greater than 10 with at least one feed material, preparing a second mixture by combining a surfactant and at least one liquid component, and combining the first mixture and the second mixture to provide the ruminant feed mixture.

In some embodiments, the fatty acid component is in a free flowing solid form.

In some embodiments, the fatty acid component comprises a rumen stable fatty acid.

In some embodiments, the fatty acid component melts at not less than about 40°C.

In some embodiments, the fatty acid component melts at not less than about 50°C.

In some embodiments, the fatty acid component melts at not less than about 60°C.

In some embodiments, the fatty acid component melts at about 63°C.

In some embodiments, the fatty acid component comprises at least 90% of a palmitic acid compound by weight.

In some embodiments, the fatty acid component comprises at least 98% of a palmitic acid compound by weight.

In some embodiments, the palmitic acid compound comprises free palmitic acid, palmitate triglyceride, sodium palmitate, calcium palmitate, magnesium palmitate, or ammonium palmitate.

In some embodiments, the fatty acid component comprises at least 98% of free palmitic acid by weight.

In some embodiments, the free palmitic acid is in prilled bead form. In some embodiments, the free palmitic acid is in flake form.

In some embodiments, the fatty acid component consists essentially of a palmitic acid compound and a stearic acid compound.

In some embodiments, the fatty acid component comprises a stearic acid compound.

In some embodiments, the stearic acid compound comprises free stearic acid, stearate triglyceride, sodium stearate, calcium stearate, magnesium stearate, or ammonium stearate.

In some embodiments, the fatty acid component consists essentially of free palmitic acid and free stearic acid having a weight:weight ratio from about 10:1 to about 1:10. In some embodiments, the ratio is from about 6:4 to about 4:6. In some embodiments, the ratio is from about 8:2 to about 2:8.

In some embodiments, the fatty acid component has a moisture level no greater than 5% by weight.

In some embodiments, the fatty acid component has a moisture level no greater than 1% by weight.

In some embodiments, the fatty acid component comprises unsaponifiable matter no greater than 5% by weight.

In some embodiments, the fatty acid component comprises unsaponifiable matter no greater than 3% by weight.

In some embodiments, the fatty acid component comprises unsaponifiable matter no greater than 1.5% by weight.

In some embodiments, the fatty acid component has an Iodine Value not greater than 5.

In some embodiments, the fatty acid component has an Iodine Value not greater than 2.

In some embodiments, the fatty acid component has an Iodine Value not greater than 1.

In some embodiments, the fatty acid component has an Iodine Value not greater than 0.5.

In some embodiments, the feed material has an average particle size not greater than 20mm.

In some embodiments, the feed material has an average particle size from about 10μm to about 10mm.

In some embodiments, the feed material comprises a roughage, a forage, a silage, a grain, or an oilseed meal.

In some embodiments, the feed material comprises a polysaccharide, an oligosaccharide, a cellulose, a hemicellulose, a lignocellulose, a sugar, or a starch.

In some embodiments, the feed material is derived from wood.

In some embodiments, the feed material comprises sugar beet pulp, sugar cane, wheat bran, oat hulls, grain hulls, soybean hulls, peanut hulls, brewery by-product, yeast derivatives, grasses, hay, seeds, fruit peels, fruit pulps, legumes, plant-based feedstuffs, wheat, corn, oats, sorghum, millet, algae, or barley.

In some embodiments, the feed material comprises soy meals, bean meals, rapeseed meals, sunflower meals, coconut meals, olive meals, linseed meals, grapeseed meals, cottonseed meals, or mixtures thereof.

In some embodiments, the feed material comprises a glucogenic precursor, a vitamin, a mineral, an amino acid, an amino acid derivative, an antioxidant, a prebiotic, a probiotic, a trace element, or an antibiotic.

In some embodiments, the glucogenic precursor is glycerol, propylene glycol, glycerin, propanediol, sodium propionate, polyol, or calcium propionate.

In some embodiments, the vitamin is biotin, vitamin A, vitamin C, vitamin D, vitamin E, vitamin B, vitamin K, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_5, vitamin B_6, vitamin B_7, vitamin B_9, vitamin B_{12}, or vitamin B_p.

In some embodiments, the mineral is calcium, sodium, magnesium, phosphorous, potassium, manganese, zinc, selenium, copper, iodine, iron, cobalt, molybdenum, amino acid chelated or glycinated minerals, or selenium yeast.

In some embodiments, the amino acid is carnitine, histidine, alanine, isoleucine, arginine, leucine, asparagine, lysine, aspartic acid, methionine, cysteine, phenylalanine, glutamic acid, threonine, glutamine, tryptophan, glycine, valine, ornithine, proline, selenocysteine, serine, tyrosine, or selenomethionine.

In some embodiments, the antioxidant is a flavonoid, or flavone, or a quinone.

In some embodiments, the antibiotic is monensine, bambermycin, lasalocid, salinomycin, an essential oil, an alkaloid, a sesquiterpene, a terpene, or their derivative thereof.

In some embodiments, the first mixture has a moisture level of not greater than 12% by weight.

In some embodiments, the first mixture has a moisture level of not greater than 10% by weight.

In some embodiments, the first mixture has a moisture level of from about 1% by weight to about 10% by weight.

In some embodiments, the first mixture has particles sized not greater than 20mm.

In some embodiments, the first mixture has particles sized from about 10μm to about 10mm.

In some embodiments, the surfactant comprises a non-ionic emulsifier.

In some embodiments, the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of about 5 to about 14.

In some embodiments, the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of not greater than about 10.

In some embodiments, the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of at least about 7.

In some embodiments, the surfactant comprises lecithin, soy lecithin, cephalin, castor oil ethoxylate, sorbitan monooleate, tallow ethoxylate, lauric acid, or polyethylene glycol.

In some embodiments, surfactant comprises calcium stearoyl dilaciate, polyglycerol ester, sorbitan ester, polyethylene glycol ester, sugar ester, monoglyceride, acetylated monoglyceride, or lactylated monoglyceride.

In some embodiments, the surfactant comprises polyoxyethylene stearate, polysorbate, polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monooleate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan tristearate, ammonium phosphatides, sodium or potassium or calcium salts of fatty acids, magnesium salts of fatty acids, mono- and diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, lactic acid esters of mono- and diglycerides of fatty acids, citric acid esters of mono- and diglycerides of fatty acids, mono- and diacetyl tartaric acid esters of mono- and diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, tartaric acid esters of mono- and diglycerides of fatty acids, sucrose esters of fatty acids sucroglycerides, polyglycerol esters of fatty acids polyglycerol polyricinoleate, propane-1,2-diol esters of fatty acids, thermally oxidized soya bean oil interacted with mono- and diglycerides of fatty acids, sodium stearoyl-2-lactylate, calcium stearoyl-2-lactylate,

sorbitan monostearate, sorbitan tristearate, sorbitan monolaurate, sorbitan monooleate, or sorbitan monopalmitate.

In some embodiments, a weight:weight ratio of the surfactant to the fatty acid component is about 1:1000 to about 1:5.

In some embodiments, a weight:weight ratio of the surfactant to the fatty acid component is about 1:50 to about 1:35.

In some embodiments, a weight:weight ratio of the surfactant to the liquid component is about 1:1 to about 1:100.

In some embodiments, a weight:weight ratio of the surfactant to the liquid component is about 1:10.

In some embodiments, the volume:volume ratio of the surfactant to the liquid component is about 1:1 to about 1:100.

In some embodiments, the volume:volume ratio of the surfactant to the liquid component is about 1:10 to about 1:30.

In some embodiments, the liquid component comprises water.

In some embodiments, the liquid component comprises water not less than 90% by volume.

In some embodiments, the liquid component comprises water not less than 98% by volume.

In some embodiments, the liquid component comprises water not less than 99.5% by volume.

In some embodiments, the liquid component comprises a glucogenic precursor.

In some embodiments, the liquid component comprises glycerol, propylene glycol, glycerin, polyol, propanediol, vinasse or molasses.

In some embodiments, the second mixture is an emulsion.

In some embodiments, the ruminant feed mixture comprises the surfactant from about 0.001% to about 10% by weight.

In some embodiments, the ruminant feed mixture comprises the surfactant from about 0.01% to about 5% by weight.

In some embodiments, the ruminant feed mixture comprises the fatty acid component from about 2% to about 50% by weight.

In some embodiments, the ruminant feed mixture comprises the fatty acid component from about 3% to about 15% by weight.

In some embodiments, the ruminant feed mixture comprises the fatty acid component from about 10% to about 20% by weight.

In some embodiments, the ruminant feed mixture comprises about 10% of the fatty acid component by weight.

In some embodiments, preparing the second mixture is carried out at ambient temperature.

In some embodiments, preparing the second mixture is carried out at a temperature greater than or equal to a temperature sufficient to melt the fatty acid component.

In some embodiments, mixing is carried out by spraying the second mixture into the first mixture.

In some embodiments, the second mixture is sprayed into the first mixture in a mist having a particle size not greater than 1500μm.

In some embodiments, the second mixture is sprayed into the first mixture in a mist having a particle size from about 1μm to about 1500μm.

In some embodiments, the second mixture is sprayed into the first mixture over a period of time not less than 20 seconds.

In some embodiments, the second mixture is sprayed into the first mixture over a period of time from about 20 seconds to about 60 seconds.

In some embodiments, the second mixture is sprayed into the first mixture over a period of time from about 30 seconds to about 40 seconds.

In some embodiments, mixing of the first mixture with the second mixture is carried out at ambient temperature.

In some embodiments, mixing of the first mixture with the second mixture is carried out at a temperature sufficient to melt the fatty acid component.

In some embodiments, mixing of the first mixture with the second mixture is carried out at room temperature.

In some embodiments, before preparing the first mixture, the feed material is ground to an average particle size of about 1 mm to about 10 mm.

In some embodiments, the ruminant feed mixture is formed into pellets.

In some embodiments, forming the ruminant feed mixture into pellets includes steam conditioning the ruminant feed mixture for a period of conditioning time to provide

a steam-conditioned ruminant feed mixture at a steam conditioning temperature, and pressing the steam-conditioned ruminant feed mixture into pellets.

In some embodiments, the period of conditioning time is from about 15 seconds to about 30 minutes.

In some embodiments, the period of conditioning time is from about 30 seconds to about 30 minutes.

In some embodiments, the period of conditioning time is from about 15 minutes to about 30 minutes.

In some embodiments, the steam conditioning temperature is not less than a temperature sufficient to melt the fatty acid component.

In some embodiments, the steam conditioning temperature is about 65°C to about 75°C.

In some embodiments, the steam conditioning temperature is about 73°C to about 75°C.

In some embodiments, the pellets reach not less than about 78°C after the pressing step.

In some embodiments, the pellets reach not less than about 81°C after the pressing step.

In some embodiments, the pellets are cooled to ambient temperature after pressing.

In some embodiments, a system for making a ruminant feed, includes a first mixer, wherein the first mixer contains a first mixture comprising a fatty acid component having an Iodine Value no greater than 10 and at least one feed material, a second mixer wherein the second mixer contains a second mixture comprising a surfactant and at least one liquid component and wherein the second mixer is in communication with the first mixer, a steam conditioning vessel in communication with the first and the second mixers wherein the steam conditioning vessel contains a ruminant feed mixture comprising a first mixture and a second mixture; and a pellet presser or extruder in communication with the steam conditioning vessel.

In some embodiments, the system further includes a third mixer in communication with the first mixer and the second mixer, wherein the first mixture and the second mixture are combined in the third mixer.

In some embodiments, the first mixer includes a paddle mixer or a ribbon mixer.

In some embodiments, the pellet presser has a ring die presser.

In some embodiments, the ring die presser has a die diameter from about 4mm to about 6mm.

In some embodiments, the ring die presser has a die channel from about 40mm to about 120mm.

In some embodiments, a method of increasing milk fat content of milk produced by a ruminant, includes providing a ruminant feed mixture to the ruminant for ingestion, wherein the ruminant feed mixture is made by the method of any one of the embodiments described, and collecting milk from the ruminant after the ruminant has ingested the ruminant feed mixture, wherein milk collected from the ruminant has a higher milk fat content compared to milk before the ruminant ingested the ruminant feed mixture.

In some embodiments, the ruminant is a cow, goat, or sheep.

In some embodiments, a ruminant dietary composition is made by the method of any one of the embodiments described.

In some embodiments, the ruminant dietary composition is a dry particle, a pellet, a liquid suspension, a paste, or an emulsion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a flow diagram of an illustrative method of preparing a ruminant feed mixture;

FIGURE 2 is a flow diagram of an illustrative method of preparing pellets from the ruminant feed mixture;

FIGURE 3 is a schematic illustration of a system for preparing the ruminant feed mixture and the pellets; and

FIGURE 4 is a diagrammatical illustration of a ring die for a ring die presser.

DETAILED DESCRIPTION

This disclosure is not limited to the particular systems, devices and methods described, as these may vary. The terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope.

As used in this document, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. Unless defined otherwise, all

technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art.

The following terms shall have, for the purposes of this application, the respective meanings set forth below.

A "ruminant" is generally a suborder of mammal with a multiple chamber stomach that gives the animal the ability to digest cellulose-based food by softening it within a first chamber (rumen) of the stomach and to regurgitate the semi-digested mass to be chewed again by the ruminant for digestion in one or more other chambers of the stomach. Examples of ruminants include, but are not limited to, lactating animals such as cattle, goats and sheep. Cattle may include dairy cows, which are generally animals of the species *Bos taurus*. The milk produced by ruminants is widely used in a variety of dairy-based products.

The present disclosure generally relates to ruminant feed mixtures, the dietary compositions made therefrom, and to the methods for making the dietary compositions that can be fed to ruminants. The dietary compositions may be configured to improve various aspects of milk production in the ruminants. For instance, some embodiments provide that the dietary compositions may increase the amount of milk production by the ruminant, increase the fat content of the milk produced by the ruminant, or both. Specific compositions described herein may include ruminant feed mixtures, supplements, or the like. According to some embodiments, the dietary compositions may include liquids, solids or combinations thereof, such as dry particles, pellets, liquid suspensions, emulsions, slurries, or the like.

When a ruminant consumes feed, the fat in the feed is modified by the rumen to provide a milk fat profile that is different from the profile of fat in the feed. All fats which are not completely inert in the rumen may decrease feed intake and rumen digestibility of the feed material. Milk composition and fat quality may be influenced by the ruminant's diet. For example, oil feeding (the feeding of vegetable oils, for example) can have negative effects on both rumen function and milk formation. As a result of oil feeding, the milk protein concentration may decrease, the fat concentration may decrease, and the proportion of trans fatty acids may increase. These results have been connected with various negative milk characteristics, such as an increase in the harmful low-density lipoprotein (LDL) cholesterol and a decrease in the beneficial high-density lipoprotein (HDL) cholesterol in human blood when the milk is consumed. In addition, the

properties of the milk fat during industrial milk processing may be weakened. A high level of polyunsaturated fatty acids in milk can also cause taste defects and preservation problems. A typical fatty acid composition of milk fat may contain more than about 70% saturated fatty acids and a total amount of trans fatty acids may be from about 3% to about 10%. When vegetable oil is added into the feed, the proportion of trans fatty acids may rise to more than about 10%.

One solution to diminishing the detrimental effect of oil and fat is to prevent triglyceride fat hydrolysis. Fat hydrolysis can be decreased, for example, by protecting fats with formaldehyde-treated casein. Another alternative is to feed the ruminant insoluble fatty acid calcium salts whereby hydrogenation in the rumen can be avoided. However, fatty acid salts typically have a pungent taste that may result in decreased feed intake by the ruminant. In addition, the salts may also disturb certain processes for forming the feed into pellets.

A fatty acid component, described herein, may allow for the transfer of a fatty acid from the feed via the digestive tract into the blood circulation of a ruminant. This may improve the energy efficiency of milk production and the utilization of energy by the ruminant. When the utilization of energy becomes more effective, milk production may increase and the concentrations of protein and fat in the milk may rise. According to some embodiments, the dietary composition may be configured to enhance fat synthesis in the mammary gland by bringing milk fat components to the cell such that energy consuming synthesis in the mammary gland is not necessary. As a result, glucose may be used more efficiently for lactose production causing increased milk production. In addition, the milk protein content may increase because there is no need to produce glucose from amino acids. Accordingly, the ruminant may not lose weight at the beginning of the lactation period, thereby improving the fertility of the ruminant.

FIGURE 1 depicts a flow diagram of one embodiment of a method of preparing a ruminant feed mixture with a fatty acid component. The components described herein with respect to FIGURE 1 may generally be combined in any order, may include more or fewer components, and are not limited by the order described. In various embodiments, the dietary composition may be formulated in a manner so that when consumed by the ruminant, the dietary composition maximizes particular qualities in the milk produced by the ruminant, as well as an amount of milk produced by the ruminant, as described in greater detail herein.

As depicted in FIGURE 1, a method of making a ruminant feed mixture includes preparing a first mixture by combining a "fatty acid component having an Iodine Value no greater than 10" with at least one feed material, block 102. For brevity, unless the fatty acid component is indicated to have a specific Iodine Value, the use of the abbreviated phrase "fatty acid component" herein will mean a fatty acid component deemed to have an Iodine Value no greater than 10. The fatty acid component and the feed material may be mixed in a conventional batch mixer. The method of making the ruminant feed mixture also includes preparing a second mixture by combining a surfactant and at least one liquid component, block 104. The surfactant and the at least one liquid component may be combined in a mixer, such as a conventional batch mixer. The method of making the ruminant feed mixture includes mixing the first mixture and the second mixture to provide the ruminant feed mixture, block 106. In some embodiments, the first mixture is a mixture of solids, and the second mixture is a mixture of at least one liquid. However, in other embodiments, the first mixture may include liquid components, and the second mixture may include solid components.

Referring to block 104 of FIGURE 1, the fatty acid component having an Iodine Value no greater than 10 may include one or more fatty acid compounds. In some embodiments, the fatty acid component is in a free-flowing solid form. In some embodiments, the fatty acid component is in a prilled bead form or flakes. "Prilling" refers to a process in which a material, in this case, the fatty acid component, is melted and then formed into droplets. The droplets can be allowed to solidify by dropping the droplets through the air from a prilling tower onto a collection surface. The prilled beads or flakes may undergo further processing, such as drying or sorting according to size.

The fatty acid component has an Iodine Value no greater than about 10. In some embodiments, the fatty acid component has an Iodine Value no greater than about 5. In some embodiments, the fatty acid component has an Iodine Value no greater than about 2. In some embodiments, the fatty acid component has an Iodine Value no greater than about 1. In some embodiments, the fatty acid component can have an Iodine Value no greater than about 0.5. The Iodine Value is also sometimes referred to in the literature as the Iodine Number. The Iodine Value provides a measure of the unsaturation of a chemical material. Accordingly, the fatty acid component may include some unsaturated fatty acid compounds. The Iodine Value is a measure of iodine absorbed in a given amount of time by the fatty acid component. For example, the Iodine Value can represent

the number of grams of iodine consumed by 100 grams of the fatty acid component. The lower the Iodine Value is, the lower the degree of unsaturation. A well-known method of determining the Iodine Value is the Wijs Method. However, the disclosure is not limited to using any one specific method of determining the Iodine Value. It is also possible that other methods of determining the degree of unsaturation may not involve the use of iodine or another halogen. It is therefore intended herein that the "Iodine Value" gives a representation of the degree of unsaturation by whatever method, and is not to be construed as limited solely to the iodine method.

In some embodiments, the fatty acid component may include a mixture of fatty acid compounds. The fatty acid compounds of the fatty acid component may be selected so that their melting points ensure that the fatty acid compounds are inert in the rumen environment. In some embodiments, the fatty acid component may include a rumen stable fatty acid. In some embodiments, the fatty acid compounds have a melting point that is less than the temperature of the rumen environment. In some embodiments, the fatty acid component melts at not less than about 40°C. In some embodiments, the fatty acid component melts at not less than about 50°C. In some embodiments, the fatty acid component melts at not less than about 60°C. In some embodiments, the fatty acid component melts at about 63°C.

A fatty acid compound may include a fatty acid salt, a fatty acid ester, a fatty acid amide, a fatty acid anhydride, or a fatty acid alcohol.

A fatty acid salt may be any acid addition salt, including, but not limited to, halogenic acid salts such as, for example, hydrobromic, hydrochloric, hydrofluoric, and hydroiodic acid salt; an inorganic acid salt such as, for example, nitric, perchloric, sulfuric, and phosphoric acid salt; an organic acid salt such as, for example, sulfonic acid salts (methanesulfonic, trifluoromethane sulfonic, ethanesulfonic, benzenesulfonic, or p-toluenesulfonic), acetic, malic, fumaric, succinic, citric, benzoic, gluconic, lactic, mandelic, mucic, pamoic, pantothenic, oxalic, and maleic acid salts; and an amino acid salt such as aspartic or glutamic acid salt. The acid addition salt may be a mono- or di-acid addition salt, such as a di-hydrohalogenic, di-sulfuric, di-phosphoric, or di-organic acid salt. In all cases, the acid addition salt is used as an achiral reagent which is not selected on the basis of any expected or known preference for interaction with or precipitation of a specific optical isomer of the products of this disclosure.

A fatty acid ester includes, for example, a fatty acid ester in a form of RCOOR'. R may be any saturated or unsaturated alkyl group including, without limitation, C10, C12, C14, C16, C18, C20, and C24. R' may be any group having from about 1 to about 1000 carbon atoms and with or without hetero atoms. In some embodiments, R' may have from about 1 to about 20, from about 3 to about 10, and from about 5 to about 15 carbon atoms. The hetero atoms may include, without limitation, N, O, S, P, Se, halogen, Si, and B. For example, R' may be a C_{1-6}alkyl, such as methyl, ethyl or t-butyl; a C_{1-6}alkoxyC_{1-6}alkyl; a heterocyclyl, such as tetrahydrofuranyl; a C_{6-10}aryloxyC_{1-6}alkyl, such as benzyloxymethyl (BOM); a silyl, such as trimethylsilyl, t-butyldimethylsilyl and t-butyldiphenylsilyl; a cinnamyl; an allyl; a C_{1-6}alkyl which is mono-, di- or trisubstituted by halogen, silyl, cyano or C_{1-6}aryl, wherein the aryl ring is unsubstituted or substituted by one, two or three, residues selected from the group consisting of C_{1-7}alkyl, C_{1-7}alkoxy, halogen, nitro, cyano and CF_3; or a C_{1-2}alkyl substituted by 9-fluorenyl.

As used herein, a fatty acid amide may generally include amides of fatty acids where the fatty acid is bonded to an amide group. For example, the fatty acid amide may have a formula of RCONR'R". R may be any saturated or unsaturated alkyl group including, without limitation, C10, C12, C14, C16, C18, C20, and C24. R' and R" may be any group having from about 1 to about 1000 carbon atoms and with or without hetero atoms. In some embodiments, R' may have from about 1 to about 20, from about 3 to about 10, and from about 5 to about 15 carbon atoms. The hetero atoms may include, without limitation, N, O, S, P, Se, halogen, Si, and B. For example, R' and R" each may be an alkyl, an alkenyl, an alkynyl, an aryl, an aralkyl, a cycloalkyl, a halogenated alkyl, or a heterocycloalkyl group.

A fatty acid anhydride may generally refer to a compound which results from the condensation of a fatty acid with a carboxylic acid. Illustrative examples of carboxylic acids that may be used to form a fatty acid anhydride include acetic acid, propionic acid, benzoic acid, and the like.

A fatty acid alcohol refers to a fatty acid having straight or branched, saturated, radical groups with 3-30 carbon atoms, and one or more hydroxy groups. The alkyl portion of the alcohol component can be propyl, butyl, pentyl, hexyl, iso-propyl, iso-butyl, sec-butyl, tert-butyl, or the like. One of skill in the art may appreciate that other alcohol groups may also useful in the present disclosure.

The fatty acid component may include a palmitic acid compound. The palmitic acid compound is not limited by this disclosure, and may include one or more of a conjugated palmitic acid, unconjugated palmitic acid, free palmitic acid, and palmitic acid derivatives. Palmitic acid, also known as hexadecanoic acid, has a molecular formula of $CH_3(CH_2)_{14}CO_2H$. Non-limiting examples of palmitic acid derivatives include palmitic acid esters, palmitic acid amides, palmitic acid salts, palmitic acid carbonates, palmitic acid carbamates, palmitic acid imides, and palmitic acid anhydrides. According to some embodiments, the palmitic acid compound may include free palmitic acid, palmitate triglyceride, sodium palmitate, calcium palmitate, magnesium palmitate, or ammonium palmitate.

The palmitic acid compound may be present in the fatty acid component in an amount of at least about 90% by weight of the fatty acid component. In some embodiments, the palmitic acid compound may be present in the fatty acid component in an amount of at least about 98% by weight of the fatty acid component. In an embodiment, the fatty acid component may include at least 98% of free palmitic acid by weight. In an embodiment, the fatty acid component may consist of about 100% of the palmitic acid compound. In other words, the fatty acid component is palmitic acid. In an embodiment, the free palmitic acid is in prilled bead form. In another embodiment, the free palmitic acid is in flake form.

In some embodiments, the fatty acid component may include a stearic acid compound. The stearic acid compound is not limited by this disclosure, and may include conjugated stearic acid, unconjugated stearic acid, free stearic acid, and stearic acid derivatives. Stearic acid, also known as octadecanoic acid, has a molecular formula of $CH_3(CH_2)_{16}CO_2H$. Specific examples of stearic acid derivatives may include stearic acid esters, stearic acid amides, stearic acid salts, stearic acid carbonates, stearic acid carbamates, stearic acid imides, and stearic acid anhydrides. In some embodiments, the fatty acid component substantially does not contain a stearic acid compound. In some embodiments, the fatty acid component consists essentially of a palmitic acid compound and a stearic acid compound. In some embodiments, the stearic acid compound comprises free stearic acid, stearate triglyceride, sodium stearate, calcium stearate, magnesium stearate, or ammonium stearate. In some embodiments, the fatty acid component consists essentially of free palmitic acid and free stearic acid having a weight:weight ratio from about 10:1 to about 1:10. In some embodiments, the ratio is

from about 6:4 to about 4:6. In some embodiments, the ratio is from about 8:2 to about 2:8. In some embodiments, the fatty acid component has a moisture level no greater than 5% by weight. In some embodiments, the fatty acid component has a moisture level no greater than 1% by weight. In some embodiments, the fatty acid component has a moisture level not greater than 0.01% by weight. In some embodiments, the fatty acid component has a moisture level not less than 0.01% by weight. In some embodiments, the fatty acid component includes unsaponifiable matter no greater than 5% by weight. In some embodiments, the fatty acid component includes unsaponifiable matter no greater than 3% by weight. In some embodiments, the fatty acid component includes unsaponifiable matter no greater than 1.5% by weight.

In some embodiments, the fatty acid component may include one or more free fatty acids and/or glycolipids.

Referring to block 102 of FIGURE 1, the feed material may include one or more carbohydrate components, one or more nitrogen components, or both carbohydrate and nitrogen components. The carbohydrate component of the feed material may generally include at least one of a sugar, a starch, or a grain. Non-limiting examples of carbohydrate feed materials include molasses, sugar beet pulp, sugarcane, wheat bran, oat hulls, grain hulls, soybean hulls, peanut hulls, wood, brewery byproducts, beverage industry byproducts, forages, roughages, silages, molasses, sugars, starches, cellulose, hemicellulose, wheat, corn, oats, sorghum, millet, barley, barley fiber, barley hulls, barley middlings, barley bran, malting barley screenings, malting parley and fines, malt rootlets, maize bran, maize middlings, maize cobs, maize screenings, maize fiber, millet, rice, rice bran, rice middlings, rye, triticale, brewers grain, coffee grinds, tea leaf fines, citrus fruit pulp, rind residues, algae, algae meal, and microalgae. Non-limiting examples of nitrogen feed materials include microalgae, oilseed meals, soy meals, bean meals, rapeseed meals, sunflower meals, coconut meals, olive meals, linseed meals, grapeseed meals, distiller dry grains solids, camelina meal, camelina expeller, cotton seed meal, cotton seed expeller, linseed expeller, palm meal, palm kernel meal, palm expeller, rapeseed expeller, potato protein, olive pulp, horse beans, peas, wheat germ, corn germ, corn germ pressed fiber meal residue, corn germ protein meal, whey protein concentrate, milk protein slurries, milk protein powders, and animal protein. In some embodiments, the feed material may include a roughage, a silage, a grain, or an oilseed meal. In some embodiments, the feed material may include a polysaccharide, an oligosaccharide, a

cellulose, a hemicellulose, a lignocellulose, a sugar, or a starch. In some embodiments, the feed material is derived from wood. In some embodiments, the feed material includes sugar beet pulp, sugar cane, wheat bran, oat hulls, grain hulls, soybean hulls, peanut hulls, brewery by-product, yeast derivatives, grasses, hay, seeds, fruit peels, fruit pulps, legumes, plant-based feedstuffs, wheat, corn, oats, sorghum, millet, algae, or barley. In some embodiments, the feed material includes soy meals, bean meals, rapeseed meals, sunflower meals, coconut meals, olive meals, linseed meals, grapeseed meals, cottonseed meals, or mixtures thereof.

Referring to block 104 of FIGURE 1, the surfactant may include at least one emulsifier. The emulsifier may be configured to facilitate or not interfere with forming the ruminant feed mixture into pellets. In some embodiments, the surfactant may include at least one non-ionic emulsifier. In some embodiments, the hydrophilic-lipophilic balance (HLB) value of the emulsifier may be about 5, about 7, about 10, about 14, or any value or range between any two of these values (including endpoints). Sample ranges of HLB values include about 5 to about 10, about 5 to about 14, about 7 to about 10, about 7 to about 14, at least about 7, and not greater than about 10.

The HLB value provides an indication of the degree to which a surfactant is hydrophilic or lipophilic. HLB values can be determined formulaically by assigning values to certain regions of the surfactant molecule. The HLB value can be determined by one of several well-known methods, including, for example, Griffin's method.

The surfactant may include, without limitation, lecithin, soy lecithin, cephalin, castor oil ethoxylate, sorbitan monooleate, tallow ethoxylate, lauric acid, polyethylene glycol, calcium stearoyl dilaciate, polyglycerol ester, sorbitan ester, polyethylene glycol ester, sugar ester, monoglyceride, acetylated monoglyceride, or lactylated monoglyceride, polyoxyethylene stearate, polysorbate, polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monooleate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan tristearate, ammonium phosphatides, sodium or potassium or calcium salts of fatty acids, magnesium salts of fatty acids, mono- and diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, lactic acid esters of mono- and diglycerides of fatty acids, citric acid esters of mono- and diglycerides of fatty acids, mono- and diacetyl tartaric acid esters of mono- and diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, tartaric acid esters of mono- and diglycerides of fatty acids,

sucrose esters of fatty acids sucroglycerides, polyglycerol esters of fatty acids polyglycerol polyricinoleate, propane-1,2-diol esters of fatty acids, thermally oxidized soya bean oil interacted with mono- and diglycerides of fatty acids, sodium stearoyl-2-lactylate, calcium stearoyl-2-lactylate, sorbitan monostearate, sorbitan tristearate, sorbitan monolaurate, sorbitan monooleate, sorbitan monopalmitate, or any derivative or combination thereof.

Referring to block 104 of FIGURE 1, at least one liquid component is used in the second mixture. In some embodiments, the liquid component includes water. In some embodiments, the liquid component includes water not less than 90% by volume. In some embodiments, the liquid component includes water not less than 98% by volume. In some embodiments, the liquid component includes water not less than 99.5% by volume. In some embodiments, the liquid component includes a glucogenic precursor. In some embodiments, the liquid component comprises glycerol, propylene glycol, glycerin, propanediol, polyol, vinasse or molasses. In some embodiments, a weight:weight ratio of the surfactant to the fatty acid component is about 1:1000 to about 1:5. In some embodiments, the weight:weight ratio of the surfactant to the fatty acid component is about 1:50 to about 1:35. In some embodiments, the weight:weight ratio of the surfactant to the liquid component is about 1:1 to about 1:100. In some embodiments, the weight:weight ratio of the surfactant to the liquid component is about 1:10. In some embodiments, the volume:volume ratio of the surfactant to the liquid component is about 1:1 to about 1:100. In some embodiments, the volume:volume ratio of the surfactant to the liquid component is about 1:10 to about 1:30.

The ruminant feed mixture prepared according to the method depicted in FIGURE 1 is not limited to the components described in blocks 102 and 104. Other components may be included in the ruminant feed mixture according to some embodiments described herein. For instance, one or more nutrient components may be added to the ruminant feed mixture, prior to, during, or after the mixing step, block 106. In some embodiments, the one or more nutrient components may be combined in block 104 if the nutrient is a liquid or in block 102 if the nutrient is a solid component. However, solids and liquids can be added in either step. Alternatively, the nutrient may be added separately to the mixer in block 106.

The feed material may additionally include, without limitation, carnitine, at least one glucogenic precursor, at least one vitamin, at least one mineral, at least one amino

acid, at least one amino acid derivative, at least one antioxidant, at least one prebiotic, at least one probiotic, at least one trace element, at least one antibiotic, or any combination thereof. In some embodiments, the ruminant feed mixture may include an amount of carnitine. Carnitine may be included in the feed material to aid in the breakdown of fatty acids to generate metabolic energy in the ruminant. In some embodiments, carnitine may be present in a premix composition.

Non-limiting examples of a glucogenic precursor may include at least one of glycerol, propylene glycol, molasses, sodium propionate, glycerine, propanediol, polyol, calcium propionate, propionic acid, octanoic acid, steam-exploded sawdust, steam-exploded wood chips, steam-exploded wheat straw, algae, algae meal, microalgae, or combinations thereof. The glucogenic precursor may generally be included in the ruminant feed mixture to provide an energy source to the ruminant that prevents gluconeogenesis from occurring within the ruminant's body. The amount of glucogenic precursor in the ruminant feed mixture may vary.

Vitamins may include one or any combination of vitamins including, without limitation, biotin, vitamin A, vitamin B, vitamin D, vitamin E, vitamin C, and vitamin K. Specific examples of vitamin B include thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3), pantothenic acid (vitamin B_5), pyridoxine (vitamin B_6), biotin (vitamin B_7), folic acid (vitamin B_9), cobalamin (vitamin B_{12}), and choline (vitamin B_p). The amount of vitamins in the ruminant feed mixture may vary.

In some embodiments, the amino acid may include any combination of common, uncommon, essential amino acids, non-essential amino acids, including, without limitation, carnitine, histidine, alanine, isoleucine, arginine, leucine, asparagine, lysine, aspartic acid, methionine, cysteine, phenylalanine, glutamic acid, threonine, glutamine, tryptophan, glycine, valine, ornithine, proline, selenocysteine, serine, tyrosine, selenomethionine, and/or any derivative thereof. The amino acid may generally be included in the ruminant feed mixture to provide a nutritional aid in various physiological processes in the ruminant, such as, for example, increasing muscle mass, providing energy, or aiding in recovery. In some embodiments, the amino acid may be present in a premix composition. The amount of amino acids in the ruminant feed mixture may vary.

In some embodiments, the mineral may be any mineral that is a generally recognized as safe (GRAS) mineral or a combination of such minerals. The mineral may further be obtained from any mineral source that provides a bioavailable mineral. In

some embodiments, the mineral may be one or more of calcium, sodium, magnesium, potassium, phosphorous, zinc, selenium, manganese, iron, cobalt, copper, iodine, and molybdenum. Minerals may include amino acid chelated or glycinated minerals or selenium yeast. In some embodiments, the mineral may be selected from one or more of a sodium salt, a calcium salt, a magnesium salt, a cobalt salt, a manganese salt, a potassium salt, an iron salt, a zinc salt, copper sulfate, copper oxide, selenium, and a chelated mineral. Illustrative examples of sodium salts include monosodium phosphate, sodium acetate, sodium chloride, sodium bicarbonate, disodium phosphate, sodium iodate, sodium iodide, sodium tripolyphosphate, sodium sulfate, and sodium selenite. Illustrative examples of calcium salts include calcium acetate, calcium carbonate, calcium chloride, calcium gluconate, calcium hydroxide, calcium iodate, calcium iodobehenate, calcium oxide, anhydrous calcium sulfate, calcium sulfate dehydrate, dicalcium phosphate, monocalcium phosphate, and tricalcium phosphate. Illustrative magnesium salts include magnesium acetate, magnesium carbonate, magnesium oxide, and magnesium sulfate. Illustrative cobalt salts include cobalt acetate, cobalt carbonate, cobalt chloride, cobalt oxide, and cobalt sulfate. Illustrative examples of manganese salts include manganese carbonate, manganese chloride, manganese citrate, manganese gluconate, manganese orthophosphate, manganese oxide, manganese phosphate, and manganese sulfate. Illustrative examples of potassium salts include potassium acetate, potassium bicarbonate, potassium carbonate, potassium chloride, potassium iodate, potassium iodide, and potassium sulfate. Illustrative examples of iron salts include iron ammonium citrate, iron carbonate, iron chloride, iron gluconate, iron oxide, iron phosphate, iron pyrophosphate, iron sulfate, and reduced iron. Illustrative examples of zinc salts include zinc acetate, zinc carbonate, zinc chloride, zinc oxide, and zinc sulfate. The amount of minerals in the ruminant feed mixture may vary. Yeast can be provided as a source of minerals, vitamins, and amino acids. The amount of yeast in the ruminant feed mixture may vary.

In some embodiments, the antioxidant includes ethoxyquin (1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline), BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene), ascorbic acid, ascorbyl palmitate, benzoic acid, calcium ascorbate, calcium propionate, calcium sorbate, citrate acid, dilauryl thiodipropionate, distearyl thiodipropionate, erythorbic acid, formic acid, methylparaben, potassium bisulphite, potassium metabisulphite, potassium sorbate, propionic acid, propyl gallate, propyl

paraben, resin guaiae, sodium ascorbate, sodium benzoate, sodium bisulphite, sodium metabisulphite, sodium nitrite, sodium propionate, sodium sorbate, sodium sulphite, sorbic acid, stannous chloride, sulphur dioxide, THBP (trihydroxy-butyrophenone), TBHQ (tertiary-butylhydroquinone), thiodipinic acid, tocopherols, polyphenol, carotenoid, flavonoids, flavones, quinones, or derivatives thereof.

In some embodiments, the antioxidant may include a flavonoid, a flavone, or a quinone.

In some embodiments, the prebiotic agent includes fructo-oligosaccahrides, inulin, galacto-oligosaccahride, mannan-oligosaccahride, a yeast, a component of a yeast, a yeast extract, or a combination thereof.

In some embodiments, the probiotic agent comprises lactic acid-producing bacteria, live yeast cells, yeast culture, or enzymes, such as protease and amylase.

In some embodiments, the antibiotic includes monensine, bambermycin, lasalocid, salinomycin, an essential oil, an alkaloid, a sesquiterpene, a terpene, or their derivative thereof. In some embodiments, the antibiotic may include monensine.

Referring to block 102 of FIGURE 1, the first mixture is made combining the fatty acid component and the feed material, such as in a conventional batch mixer. In some embodiments, the first mixture is formed of solids. In some embodiments, the first mixture has a moisture level of not greater than 12% by weight. In some embodiments, the first mixture has a moisture level of not greater than 10% by weight. In some embodiments, the first mixture has a moisture level of from about 1% by weight to about 12% by weight. In some embodiments, the first mixture includes solids having a particle size not greater than 10mm, or not greater than about 20mm. In some embodiments, the first mixture includes solids having a particle size from about 10μm to about 8mm, or from about 10μm to about 10mm.

Referring to block 104 of FIGURE 1, the second mixture is made by combining the surfactant and the at least one liquid component. In some embodiments, the initially formed mixture of surfactant and liquid may be homogenized by passing the mixture through a homogenizer one or more times or through the use of in-line dosing equipment. In some embodiments, the second mixture is an emulsion. In some embodiments, the surfactant and the water can be used as a spray mixture that is sprayed into the mixer containing the first mixture. The spray mixture can consist essentially of the surfactant and the water, or the spray mixer can consist of the surfactant and the water. That is, the

spray mixture can include only the surfactant and the water. However, when there are additional liquid components, the additional liquid components can be combined in the second mixture. In some embodiments, the second mixture is prepared at ambient temperature. In some embodiments, the second mixture is prepared at a temperature greater than or equal to a temperature sufficient to melt the fatty acid component.

Referring to block 106 of FIGURE 1, the ruminant feed mixture may be prepared by combining the first mixture with the second mixture. For example, the first mixture and the second mixture may be combined in a mixer, such as a conventional batch mixer. The first mixture can be created in the batch mixer and then, the second mixture is applied to the first mixture in the batch mixer. Alternatively, the first and second mixtures are prepared in respective separate mixers. Then, the first and second mixtures are combined in a third mixer.

In some embodiments, mixing the first mixture with the second mixture includes spraying the second mixture formed as a liquid onto the first mixture. In some embodiments, the second mixture is sprayed into the first mixture in a mist having a particle size not greater than 1500μm. In some embodiments, the second mixture is sprayed into the first mixture in a mist having a particle size from about 1μm to about 1500μm. In some embodiments, the second mixture is sprayed into the first mixture over a period of time not less than 20 seconds. In some embodiments, the second mixture is sprayed into the first mixture over a period of time from about 20 seconds to about 60 seconds. In some embodiments, the second mixture is sprayed into the first mixture over a period of time from about 30 seconds to about 40 seconds. In some embodiments, mixing, block 106, is carried out at ambient temperature. In some embodiments, mixing is carried out at a temperature sufficient to melt the fatty acid component. In some embodiments, mixing is carried out at room temperature. Preparing the ruminant feed mixture at a temperature that is greater than or equal to a temperature at which the fatty acid component melts may allow the fatty acid component to slowly melt and spread with the help of the surfactant evenly on the surface of the feed material. In some embodiments, the ruminant feed mixture may be prepared at or about room temperature (for instance, about 20°C), and subsequently heated to a temperature that is greater than or equal to the temperature at which the fatty acid component melts.

Mixing of the first and second mixtures, block 106, results in the ruminant feed mixture. In some embodiments, the ruminant feed mixture includes from about 0.001%

by weight to about 10% by weight of the surfactant. In some embodiments, the ruminant feed mixture includes from about 0.01% by weight to about 5% by weight of the surfactant. In some embodiments, the ruminant feed mixture includes from about 2% by weight to about 50% by weight of the fatty acid component. In some embodiments, the ruminant feed mixture includes from about 3% by weight to about 15% by weight of the fatty acid component. In some embodiments, the ruminant feed mixture includes from about 10% by weight to about 20% by weight of the fatty acid component. In some embodiments, the ruminant feed mixture includes about 10% of the fatty acid component by weight.

The ruminant feed mixture prepared according to embodiments described herein, such as the method depicted in FIGURE 1, may be more stable and more digestible by ruminants in a manner that leads to improved milk production, milk fat content, or both. In this manner, a ruminant may ingest a ruminant feed mixture to improve milk production and/or milk fat content.

Referring to block 108 of FIGURE 1, the method of preparing the ruminant feed mixture may optionally include grinding the feed material before the feed material is combined with the fatty acid component in block 102. Grinding the feed material may reduce the size of the feed material to an average particle size of about 1 mm to about 10 mm. The feed material may be ground to a particle size of about 0.001mm, 0.01mm, 0.1mm, 1mm, 2mm, 7mm, or 10mm, or any ranges between any two of these values (including endpoints), such as 0.1mm to 7mm, or 0.1mm to 10mm, or 1mm to 1.5 mm. Grinding the fatty acid component is optional.

After block 106, the ruminant feed mixture may be formed into pellets. Referring to FIGURE 2, the processes for forming the ruminant feed mixture into pellets includes steam conditioning the ruminant feed mixture for a period of conditioning time to provide a steam-conditioned ruminant feed mixture at a steam conditioning temperature, block 110, and pressing or extruding the steam-conditioned ruminant feed mixture into pellets, block 112. In some embodiments, the period of conditioning time is from about 15 seconds to about 30 minutes. In some embodiments, the period of conditioning time is from about 30 seconds to about 30 minutes. In some embodiments, the period of conditioning time is from about 15 minutes to about 30 minutes. In some embodiments, the steam conditioning temperature is not less than a temperature sufficient to melt the fatty acid component. In some embodiments, the steam conditioning temperature is about

65°C to about 75°C. In some embodiments, the steam conditioning temperature is about 73°C to about 75°C. In some embodiments, the pellets reach not less than about 78°C after pressing or extruding, block 112. In some embodiments, the pellets reach not less than about 81°C after pressing or extruding, block 112.

Referring to block 114 of FIGURE 2, after pressing or extruding into pellets in block 112, the pellets may be cooled to ambient temperature in block 114.

Referring to FIGURE 3, one embodiment of a system for making the ruminant feed mixture and pellets is illustrated. It is to be appreciated that some components are not shown. It is also to be appreciated that some system components can be rearranged, substituted for other components, or omitted entirely in order to achieve the objective of making a ruminant feed mixture and dietary composition. The system includes a first mixer, block 304, wherein the first mixer contains a first mixture including a fatty acid component having an Iodine Value no greater than 10 and at least one feed material. In some embodiments, the first mixer can include a paddle mixer or a ribbon mixer. The system includes a second mixer, block 302, wherein the second mixer contains a second mixture including a surfactant and at least one liquid component and wherein the second mixer is in communication with the first mixer. Alternatively, the system may include an additional mixer, block 330, to mix the first mixture, which is then transferred into the first mixer, block 304, where the first mixture is combined with the second mixture. The system may include a steam conditioning vessel, block 306, in communication with the first mixer, wherein the steam conditioning vessel contains a ruminant feed mixture comprising the first mixture and the second mixture. The system may include a pellet presser, extruder, or expander, block 308, in communication with the steam conditioning vessel, block 306. In some embodiments, a pellet presser has a ring die presser. In some embodiments, a pellet presser has a flat die presser.

Referring to FIGURE 4, a ring die presser is diagrammatically illustrated. It is to be appreciated that a ring die presser utilizing a ring die will include other components not shown. Generally, the ring die 402 has an inner diameter and an outer diameter, the difference of which defines the thickness of the individual die channels 406. The ring die 402 has a hollow center to allow one or more gears 404. The gears 404 rotate within the interior of the ring die 402 to press the ruminant feed mixture 410 out of the plurality of die channels 406. A knife 412 can scrape the ruminant feed mixture being extruded from the die channels to produce the individual pellets 408. In some embodiments, the

ring die 402 has die channels 406 with a diameter from about 4mm to about 6mm. In some embodiments, the ring die has die channels 406 from about 40mm to about 120mm thick.

Referring back to FIGURE 3, the system may include storage silos, block 316, to store one or more of the feed materials. Each different feed material may be stored separately in a different silo. Silos may be equipped with weigh scales to properly meter the feed material in the correct proportions out of the silos. Feed material in the form of grain may be pre-ground by pre-grinders, block 318, before being stored in the silos, block 316. The pre-grinders of block 318, may be configured to separately grind each one of the feed material components before they are stored. For example, the pre-grinders may be configured to grind a nitrogen component alone and a carbohydrate component alone. Alternatively, all feed materials can be ground together in the pre-grinder.

From storage, block 316, the feed material may be metered into grinder, block 304, mixer, block 330, or mixer, block 304.

The fatty acid component, block 312, can be stored and metered separately from the feed material. The fatty acid component can be metered in the correct proportions into the mixer, block 330, the grinder, block 314, or the mixer, block 304.

In some embodiments, it might be desired to grind the first mixture before it is combined with the second mixture. In such case, the fatty acid component can be combined with the feed material in mixer, block 330, to form the first mixture, and then, the first mixture is fed into the grinder, block 314. Alternatively, the mixer, block 330, can be omitted, and the fatty acid component can be metered as in enters the grinder, block 314, separately from the feed material. In another configuration where the fatty acid component is not ground, but, the feed material is desired to be ground, the mixer, block 330, is omitted, so then, the feed material enters the grinder, block 314, from the storage silos, block 316. From the grinder, block 314, the feed material is then mixed with the fatty acid component in the mixer, block 304, to provide the first mixture.

Pre-grinders, block 318, may be configured to grind feed materials to various sizes, such as particle size (for instance, measured in millimeters), mesh sizes, surface areas, or the like. The feed materials may be ground to a particle size of about 1 millimeters, about 2 millimeters, about 5 millimeters, about 7 millimeters, about 10 millimeters, and values or ranges between any two of these values (including

endpoints). Where the first mixture is also ground in grinder, block 314, the first mixture may be ground to a particle size of about 1 millimeters, about 2 millimeters, about 5 millimeters, about 7 millimeters, about 10 millimeters, and values or ranges between any two of these values (including endpoints). In some embodiments, the various solid components may have a varying distribution of particle sizes based upon the feed material.

Pre-grinding and grinding, blocks 318 and 314, may be performed by various grinding devices known to those having ordinary skill in the art, such as a hammer mill, a roller mill, a disk mill, or the like. Grinders, blocks 318, 314, may include any process for reducing the particle size of and/or comminuting a material, such as smashing, mashing, shocking, hammering, cutting, or the like. Grinding may provide various benefits, such as improving certain characteristics of the ruminant feed mixture. For instance, even and fine particle size may improve the mixing of different feed materials and pelleting. According to certain embodiments, grinding may be configured to decrease a particle size of the feed materials, for example, to increase the surface area open for enzymes in the gastrointestinal tract, which may improve the digestibility of nutrients, and to increase the palatability of the feed.

Referring to mixer, block 302, the surfactant, block 310 and a liquid, block 311, are combined to provide the second mixture. Liquid raw materials may be stored in one or more liquid component tanks. In one embodiment, the second mixture is delivered to the mixer, block 304, via spraying. To that end, the second mixture may be pumped from the mixer, block 302, through various spray nozzles located on the mixer, block 304. The spray nozzle design and a sufficient amount of pressure can produce a mist when the mixture is sprayed.

In some embodiments, the mist droplets may have an average diameter of about 1 μm, about 2 μm, about 5 μm, about 10 μm, about 20 μm, about 25 μm, about 50 μm, about 60 μm, about 80 μm, about 100 μm, about 500 μm, about 1000 μm, and about 1500 μm. In some embodiments, the fluid droplets may have an average diameter of about 1 μm to about 2 μm, about 1 μm to about 5 μm, about 1 μm to about 10 μm, about 10 μm to about 20 μm, about 10 μm to about 50 μm, about 20 μm to about 60 μm, about 25 μm to about 80 μm, about 1 μm to about 100 μm, about 10 μm to about 100 μm, about 50 to about 100 μm, about 25 μm to about 100 μm, about 1 μm to about 200 μm, about 50 μm to about 200 μm, about 1 μm to about 500 μm, about 50 μm to about 500 μm, about 100

μm to about 500 μm, about 1 μm to about 1000 μm, about 100 μm to about 1000 μm, about 500 μm to about 1000 μm, about 1 μm to about 1500 μm, about 500 μm to about 1500 μm, about 1000 μm to about 1500 μm and any range between any of these values (including endpoints).

Referring to mixer, block 304, the ruminant feed mixture produced therein can be collected, block 332, to be used in the making of various ruminant dietary compositions.

In some embodiments, the ruminant feed mixture is used for making pellets. In such cases, the system may further include, blocks 306, 308, 322, 324, 326, and 328. After the mixer, block 304, the ruminant feed mixture may be stored in pelleting bins (not shown) wherein the temperature and relative humidity can be controlled. In some embodiments, however, the ruminant feed mixture may bypass the pelleting bins and be transferred directly to a steam conditioning vessel, block 306. The steam conditioning vessel receives steam from the boiler, block 326. The steam is used to condition the ruminant feed mixture prior to the pelleting process.

The steam conditioned ruminant feed mixture may be pressed into pellets or extruded using a pellet presser or extruder, block 308. The resulting pressed pellets may have a diameter of about 5 to about 6 mm and a thickness of about 60 mm. However, other sizes can be used.

After pressing, the pellets may be placed in pellet dryer, block 322. A blower, block 328, can blow ambient air or refrigerated and dehumidified air to be used in the pellet dryer.

The dried pellets may then undergo size-sorting via a plurality of sieves, to select pellets of a particular size. The finished pellets may be stored in silos, block 324, and thereafter bulk loaded or bag loaded for shipment. Bulk loading for example, may include loading the pellets directly into a delivery vehicle. Bag loading may include filling bags with ruminant feed mixture pellets.

The ruminant dietary compositions made from the ruminant feed mixture can be used when feeding ruminants. In some embodiments, a method of increasing milk fat content or milk production in ruminants may include providing dietary compositions including the ruminant feed mixture as described herein to the ruminant for ingestion in the form of the pellets or other manner. The ruminant dietary composition can be in the form of a dry particle, a pellet, a liquid suspension, a paste, or an emulsion. In some embodiments, providing the dietary composition to the ruminant for the ruminant to

consume may result in an increase in the production of milk or an increase in the fat content of the milk produced, or both. These increases may generally be relative to a similar ruminant that does not receive the dietary composition, an average of similar ruminants not receiving the dietary composition, or an average of the milk production quantity and fat content of the same ruminant when not provided the dietary composition. In some embodiments, the milk production in either weight or volume percent may increase by an amount of about 0.2% to about 10%, including about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, or any value or range between any two of these values (including endpoints). In some embodiments, the milk fat content may increase in either weight or volume percent by an amount of about 0.1% to about 5%, including about 0.1%, about 0.2%, about 0.3%, about 0.5%, about 1%, about 2%, or any value or range between any two of these values (including endpoints) compared to ruminants that do not ingest the dietary composition.

A method of increasing milk fat content of milk produced by a ruminant may include providing a ruminant feed mixture to the ruminant for ingestion, and collecting milk from the ruminant after the ruminant has ingested the ruminant feed mixture, wherein milk collected from the ruminant has a higher milk fat content compared to milk before the ruminant ingested the ruminant feed mixture. The ruminant can be a cow, goat, or sheep.

A method of increasing milk production by a ruminant may include providing a ruminant feed mixture to the ruminant for ingestion, and collecting milk from the ruminant after the ruminant has ingested the ruminant feed mixture, wherein the milk production from the ruminant is higher compared to a milk production before the ruminant ingested the ruminant feed mixture. The ruminant can be a cow, goat, or sheep.

In the description herein, reference is made to the accompanying drawings, which form a part hereof. In the FIGURES, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be used, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the FIGURES, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

With respect to the use of plural, singular, or both herein, those having skill in the art can translate from the plural to the singular, from the singular to the plural, or both as is appropriate to the context. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (for example, bodies of the appended claims) are generally intended as "open" terms (for example, the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," et cetera). While various compositions, methods, and devices are described in terms of "comprising" various components or steps (interpreted as meaning "including, but not limited to"), the compositions, methods, and devices can also "consist essentially of" or "consist of" the various components and steps, and such terminology should be interpreted as defining essentially closed-member groups. It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the

indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (for example, "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (for example, the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). In those instances where a convention analogous to "at least one of A, B, or C, et cetera" is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, " a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, et cetera). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or FIGURES, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, et cetera As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, et cetera As will also be understood by one skilled in the art all language such as "up to," "at least," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual

member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

Various of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art, each of which is also intended to be encompassed by the disclosed embodiments.

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of preparing a ruminant feed mixture, comprising:

preparing a first mixture by combining a fatty acid component having an Iodine Value no greater than 10 with at least one feed material;

preparing a second mixture by combining a surfactant and at least one liquid component; and

combining the first mixture and the second mixture to provide the ruminant feed mixture.

2. The method of Claim 1, wherein the fatty acid component is in free flowing solid form.

3. The method of Claim 1, wherein the fatty acid component comprises a rumen stable fatty acid.

4. The method of Claim 1, wherein the fatty acid component melts at not less than about 40°C.

5. The method of Claim 1, wherein the fatty acid component melts at not less than about 50°C.

6. The method of Claim 1, wherein the fatty acid component melts at not less than about 60°C.

7. The method of Claim 1, wherein the fatty acid component melts at about 63°C.

8. The method of Claim 1, wherein the fatty acid component comprises at least 90% of a palmitic acid compound by weight.

9. The method of Claim 8, wherein the fatty acid component comprises at least 98% of a palmitic acid compound by weight.

10. The method of Claim 8, wherein the palmitic acid compound comprises free palmitic acid, palmitate triglyceride, sodium palmitate, calcium palmitate, magnesium palmitate, or ammonium palmitate.

11. The method of Claim 1, wherein the fatty acid component comprises at least 98% of free palmitic acid by weight.

12. The method of Claim 11, wherein the free palmitic acid is in prilled bead form or flake form.

13. The method of Claim 1, wherein the fatty acid component consists essentially of a palmitic acid compound and a stearic acid compound.

14. The method of Claim 1, wherein the fatty acid component comprises a stearic acid compound.

15. The method of Claim 14, wherein the stearic acid compound comprises free stearic acid, stearate triglyceride, sodium stearate, calcium stearate, magnesium stearate, or ammonium stearate.

16. The method of Claim 1, wherein the fatty acid component consists essentially of free palmitic acid and free stearic acid having a weight:weight ratio from about 10:1 to about 1:10.

17. The method of Claim 16, wherein the ratio is from about 6:4 to about 4:6.

18. The method of Claim 16, wherein the ratio is from about 8:2 to about 2:8.

19. The method of Claim 1, wherein the fatty acid component has a moisture level no greater than 5% by weight.

20. The method of Claim 1, wherein the fatty acid component has a moisture level no greater than 1% by weight.

21. The method of Claim 1, wherein the fatty acid component comprises unsaponifiable matter no greater than 5% by weight.

22. The method of Claim 1, wherein the fatty acid component comprises unsaponifiable matter no greater than 3% by weight.

23. The method of Claim 1, wherein the fatty acid component comprises unsaponifiable matter no greater than 1.5% by weight.

24. The method of Claim 1, wherein the fatty acid component has an Iodine Value not greater than 5.

25. The method of Claim 1, wherein the fatty acid component has an Iodine Value not greater than 2.

26. The method of Claim 1, wherein the fatty acid component has an Iodine Value not greater than 1.

27. The method of Claim 1, wherein the fatty acid component has an Iodine Value not greater than 0.5.

28. The method of Claim 1, wherein the feed material has an average particle size not greater than 20mm.

29. The method of Claim 1, wherein the feed material has an average particle size from about 10μm to about 10mm.

30. The method of Claim 1, wherein the feed material comprises a roughage, a forage, a silage, a grain, or an oilseed meal.

31. The method of Claim 1, wherein the feed material comprises a polysaccharide, an oligosaccharide, a cellulose, a hemicellulose, a lignocellulose, a sugar, or a starch.

32. The method of Claim 1, wherein the feed material is derived from wood.

33. The method of Claim 1, wherein the feed material comprises sugar beet pulp, sugar cane, wheat bran, oat hulls, grain hulls, soybean hulls, peanut hulls, brewery by-product, yeast derivatives, grasses, hay, seeds, fruit peels, fruit pulps, legumes, plant-based feedstuffs, wheat, corn, oats, sorghum, millet, algae, or barley.

34. The method of Claim 1, wherein the feed material comprises soy meals, bean meals, rapeseed meals, sunflower meals, coconut meals, olive meals, linseed meals, grapeseed meals, cottonseed meals, or mixtures thereof.

35. The method of Claim 1, wherein the feed material comprises a glucogenic precursor, a vitamin, a mineral, an amino acid, an amino acid derivative, an antioxidant, a prebiotic, a probiotic, a trace element, or an antibiotic.

36. The method of Claim 35, wherein the glucogenic precursor is glycerol, propylene glycol, glycerin, propanediol, sodium propionate, polyol, or calcium propionate.

37. The method of Claim 35, wherein the vitamin is biotin, vitamin A, vitamin C, vitamin D, vitamin E, vitamin B, vitamin K, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_5, vitamin B_6, vitamin B_7, vitamin B_9, vitamin B_{12}, or vitamin B_p.

38. The method of Claim 35, wherein the mineral includes calcium, sodium, magnesium, phosphorous, potassium, manganese, zinc, selenium, copper, iodine, iron, cobalt, molybdenum, amino acid chelated or glycinated minerals, or selenium yeast.

39. The method of Claim 35, wherein the amino acid is carnitine, histidine, alanine, isoleucine, arginine, leucine, asparagine, lysine, aspartic acid, methionine, cysteine, phenylalanine, glutamic acid, threonine, glutamine, tryptophan, glycine, valine, ornithine, proline, selenocysteine, serine, tyrosine, or selenomethionine.

40. The method of Claim 35, wherein the antioxidant is a flavonoid, a flavone, or a quinone.

41. The method of Claim 35, wherein the antibiotic is monensine, bambermycin, lasalocid, salinomycin, an essential oil, an alkaloid, a sesquiterpene, a terpene, or their derivative thereof.

42. The method of Claim 1, wherein the first mixture has a moisture level of not greater than 12% by weight.

43. The method of Claim 1, wherein the first mixture has a moisture level of not greater than 10% by weight.

44. The method of Claim 1, wherein the first mixture has a moisture level of from about 1% by weight to about 10% by weight.

45. The method of Claim 1, wherein the first mixture has a particle size not greater than 20mm.

46. The method of Claim 1, wherein the first mixture has a particle size from about 10μm to about 10mm.

47. The method of Claim 1, wherein the surfactant comprises a non-ionic emulsifier.

48. The method of Claim 1, wherein the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of about 5 to about 14.

49. The method of Claim 1, wherein the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of not greater than about 10.

50. The method of Claim 1, wherein the surfactant comprises an emulsifier having a hydrophilic-lipophilic balance value of at least about 7.

51. The method of Claim 1, wherein the surfactant comprises lecithin, soy lecithin, cephalin, castor oil ethoxylate, sorbitan monooleate, tallow ethoxylate, lauric acid, or polyethylene glycol.

52. The method of Claim 1, wherein surfactant comprises calcium stearoyl dilaciate, polyglycerol ester, sorbitan ester, polyethylene glycol ester, sugar ester, monoglyceride, acetylated monoglyceride, or lactylated monoglyceride.

53. The method of Claim 1, wherein the surfactant comprises polyoxyethylene stearate, polysorbate, polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monooleate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan tristearate, ammonium phosphatides, sodium or potassium or calcium salts of fatty acids, magnesium salts of fatty acids, mono- and

diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, lactic acid esters of mono- and diglycerides of fatty acids, citric acid esters of mono- and diglycerides of fatty acids, mono- and diacetyl tartaric acid esters of mono- and diglycerides of fatty acids, acetic acid esters of mono- and diglycerides of fatty acids, tartaric acid esters of mono- and diglycerides of fatty acids, sucrose esters of fatty acids sucroglycerides, polyglycerol esters of fatty acids polyglycerol polyricinoleate, propane-1,2-diol esters of fatty acids, thermally oxidized soya bean oil interacted with mono- and diglycerides of fatty acids, sodium stearoyl-2-lactylate, calcium stearoyl-2-lactylate, sorbitan monostearate, sorbitan tristearate, sorbitan monolaurate, sorbitan monooleate, or sorbitan monopalmitate.

54. The method of Claim 1, wherein a weight:weight ratio of the surfactant to the fatty acid component is about 1:1000 to about 1:5.

55. The method of Claim 1, wherein a weight:weight ratio of the surfactant to the fatty acid component is about 1:50 to about 1:35.

56. The method of Claim 1, wherein a weight:weight ratio of the surfactant to the liquid component is about 1:1 to about 1:100.

57. The method of Claim 1, wherein a weight:weight ratio of the surfactant to the liquid component is about 1:10.

58. The method of Claim 1, wherein the volume:volume ratio of the surfactant to the liquid component is about 1:1 to about 1:100.

59. The method of Claim 1, wherein the volume:volume ratio of the surfactant to the liquid component is about 1:10 to about 1:30.

60. The method of Claim 1, wherein the liquid component comprises water.

61. The method of Claim 60, wherein the liquid component comprises water not less than 90% by volume.

62. The method of Claim 60, wherein the liquid component comprises water not less than 98% by volume.

63. The method of Claim 60, wherein the liquid component comprises water not less than 99.5% by volume.

64. The method of Claim 1, wherein the liquid component comprises a glucogenic precursor.

65. The method of Claim 1, wherein the liquid component comprises glycerol, propylene glycol, glycerin, propanediol, polyol, vinasse or molasses.

66. The method of Claim 1, wherein the second mixture is an emulsion.

67. The method of Claim 1, wherein the ruminant feed mixture comprises the surfactant from about 0.001% to about 10% by weight.

68. The method of Claim 1, wherein the ruminant feed mixture comprises the surfactant from about 0.01% to about 5% by weight.

69. The method of Claim 1, wherein the ruminant feed mixture comprises the fatty acid component from about 2% to about 50% by weight.

70. The method of Claim 1, wherein the ruminant feed mixture comprises the fatty acid component from about 3% to about 15% by weight.

71. The method of Claim 1, wherein the ruminant feed mixture comprises the fatty acid component from about 10% to about 20% by weight.

72. The method of Claim 1, wherein the ruminant feed mixture comprises about 10% of the fatty acid component by weight.

73. The method of Claim 1, wherein preparing the second mixture is carried out at ambient temperature.

74. The method of Claim 1, wherein preparing the second mixture is carried out at a temperature greater than or equal to a temperature sufficient to melt the fatty acid component.

75. The method of Claim 1, wherein mixing is carried out by spraying the second mixture into the first mixture.

76. The method of Claim 75, wherein the second mixture is sprayed into the first mixture in a mist having a particle size not greater than 1500μm.

77. The method of Claim 75, wherein the second mixture is sprayed into the first mixture in a mist having a particle size from about 1μm to about 1500μm.

78. The method of Claim 75, wherein the second mixture is sprayed into the first mixture over a period of time not less than 20 seconds.

79. The method of Claim 75, wherein the second mixture is sprayed into the first mixture over a period of time from about 20 seconds to about 60 seconds.

80. The method of Claim 75, wherein the second mixture is sprayed into the first mixture over a period of time from about 30 seconds to about 40 seconds.

81. The method of Claim 1, wherein mixing is carried out at ambient temperature.

82. The method of Claim 1, wherein mixing is carried out at a temperature sufficient to melt the fatty acid component.

83. The method of Claim 1, wherein mixing is carried out at room temperature.

84. The method of Claim 1, further comprising:

before preparing the first mixture, grinding the feed material to an average particle size of about 1 mm to about 10 mm.

85. The method of Claim 1, further comprising forming the ruminant feed mixture into pellets.

86. The method of Claim 85, wherein forming the ruminant feed mixture into pellets comprises:

steam conditioning the ruminant feed mixture for a period of conditioning time to provide a steam-conditioned ruminant feed mixture at a steam conditioning temperature; and

pressing the steam-conditioned ruminant feed mixture into pellets.

87. The method of Claim 86, wherein the period of conditioning time is from about 15 seconds to about 30 minutes.

88. The method of Claim 86, wherein the period of conditioning time is from about 30 seconds to about 30 minutes.

89. The method of Claim 86, wherein the period of conditioning time is from about 15 minutes to about 30 minutes.

90. The method of Claim 86, wherein the steam conditioning temperature is not less than a temperature sufficient to melt the fatty acid component.

91. The method of Claim 86, wherein the steam conditioning temperature is about 65°C to about 75°C.

92. The method of Claim 86, wherein the steam conditioning temperature is about 73°C to about 75°C.

93. The method of Claim 86, wherein the pellets reach not less than about 78°C after the pressing.

94. The method of Claim 86, wherein the pellets reach not less than about 81°C after the pressing.

95. The method of Claim 86, further comprising cooling the pellets to ambient temperature.

96. A system for making a ruminant feed, comprising

a first mixer, wherein the first mixer contains a first mixture comprising a fatty acid component having an Iodine Value no greater than 10 and at least one feed material;

a second mixer, wherein the second mixer contains a second mixture comprising a surfactant and at least one liquid component and wherein the second mixer is in communication with the first mixer;

a steam conditioning vessel in communication with the first and the second mixers, wherein the steam conditioning vessel contains a ruminant feed mixture comprising a first mixture and a second mixture; and

a pellet presser or extruder in communication with the steam conditioning vessel.

97. The system of Claim 96, further comprising a third mixer in communication with the first mixer and the second mixer, wherein the first mixture and the second mixture are combined in the third mixer.

98. The system of Claim 96, wherein the first mixer comprises a paddle mixer or a ribbon mixer.

99. The system of Claim 96, wherein the pellet presser has a ring die presser.

100. The system of Claim 96, wherein the ring die presser has a die diameter from about 4mm to about 6mm.

101. The system of Claim 96, wherein the ring die presser has a die channel from about 40mm to about 120mm.

102. A method of increasing milk fat content of milk produced by a ruminant, comprising:

providing a ruminant feed mixture to the ruminant for ingestion, wherein the ruminant feed mixture is made by the method of any one of Claims 1-95; and

collecting milk from the ruminant after the ruminant has ingested the ruminant feed mixture, wherein milk collected from the ruminant has a higher milk fat content compared to milk before the ruminant ingested the ruminant feed mixture.

103. The method of Claim 102, wherein the ruminant is a cow, goat, or sheep.

104. A ruminant dietary composition made by the method of any one of Claims 1-95.

105. The ruminant dietary composition of Claim 104, wherein the ruminant dietary composition is a dry particle, a pellet, a liquid suspension, a paste, or an emulsion.

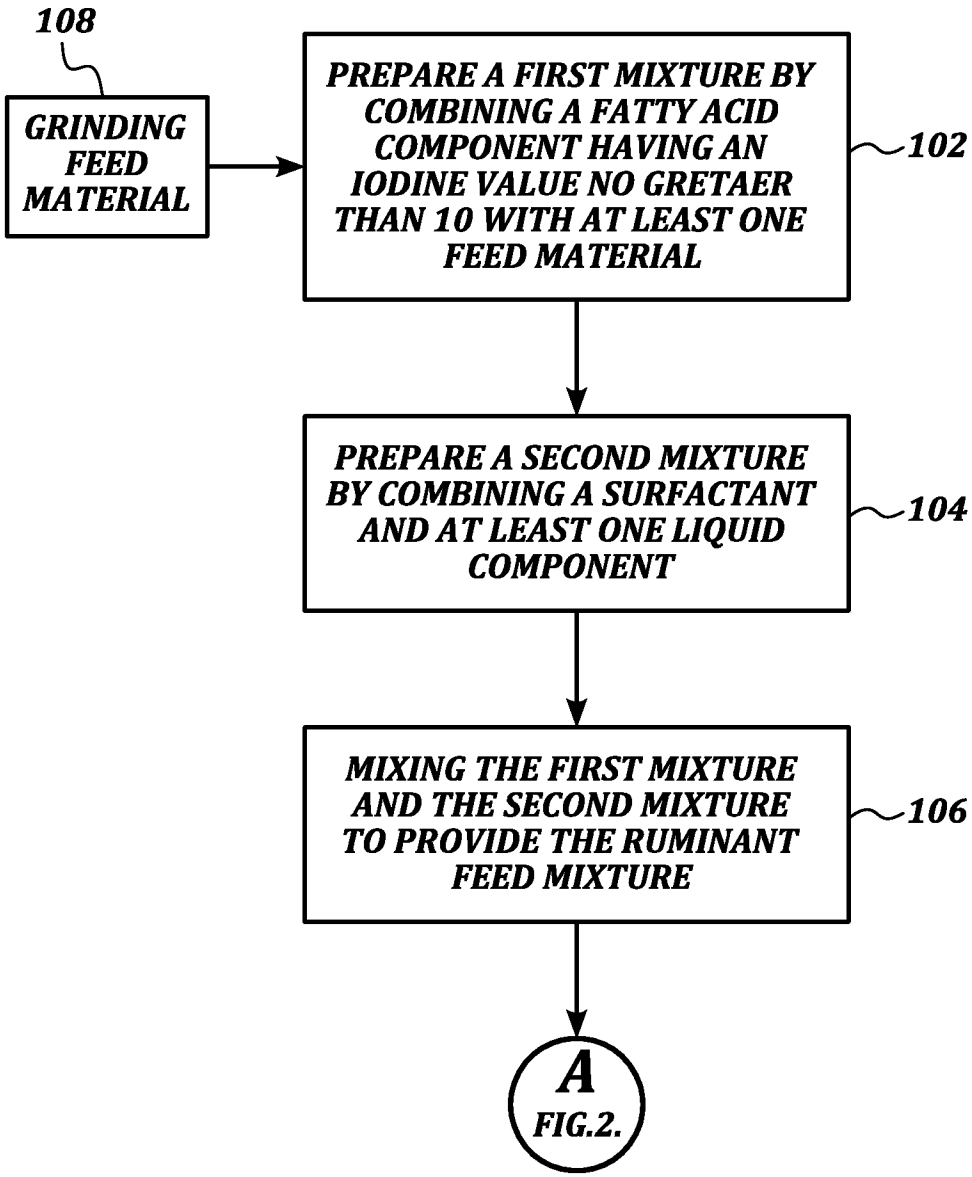
108
GRINDING FEED MATERIAL
PREPARE A FIRST MIXTURE BY COMBINING A FATTY ACID COMPONENT HAVING AN IODINE VALUE NO GRETAER THAN 10 WITH AT LEAST ONE FEED MATERIAL
102
PREPARE A SECOND MIXTURE BY COMBINING A SURFACTANT AND AT LEAST ONE LIQUID COMPONENT
104
MIXING THE FIRST MIXTURE AND THE SECOND MIXTURE TO PROVIDE THE RUMINANT FEED MIXTURE
106
A
FIG.2.

FIG. 1

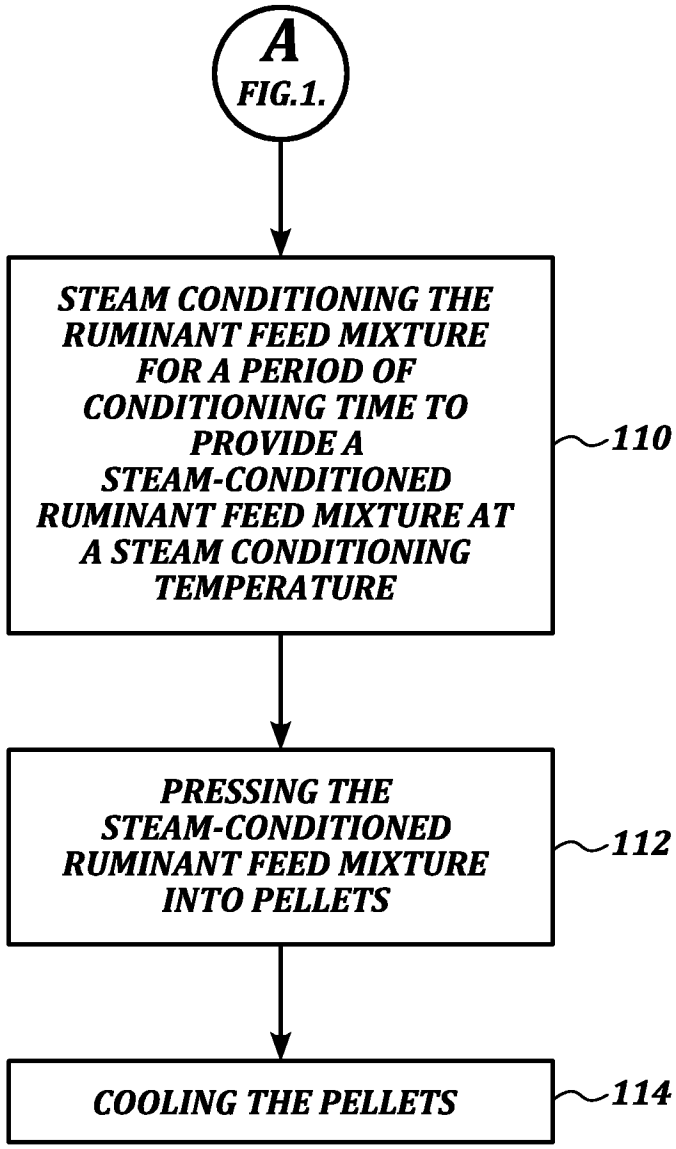
A
FIG.1.
STEAM CONDITIONING THE RUMINANT FEED MIXTURE FOR A PERIOD OF CONDITIONING TIME TO PROVIDE A STEAM-CONDITIONED RUMINANT FEED MIXTURE AT A STEAM CONDITIONING TEMPERATURE
110
PRESSING THE STEAM-CONDITIONED RUMINANT FEED MIXTURE INTO PELLETS
112
COOLING THE PELLETS
114

FIG. 2

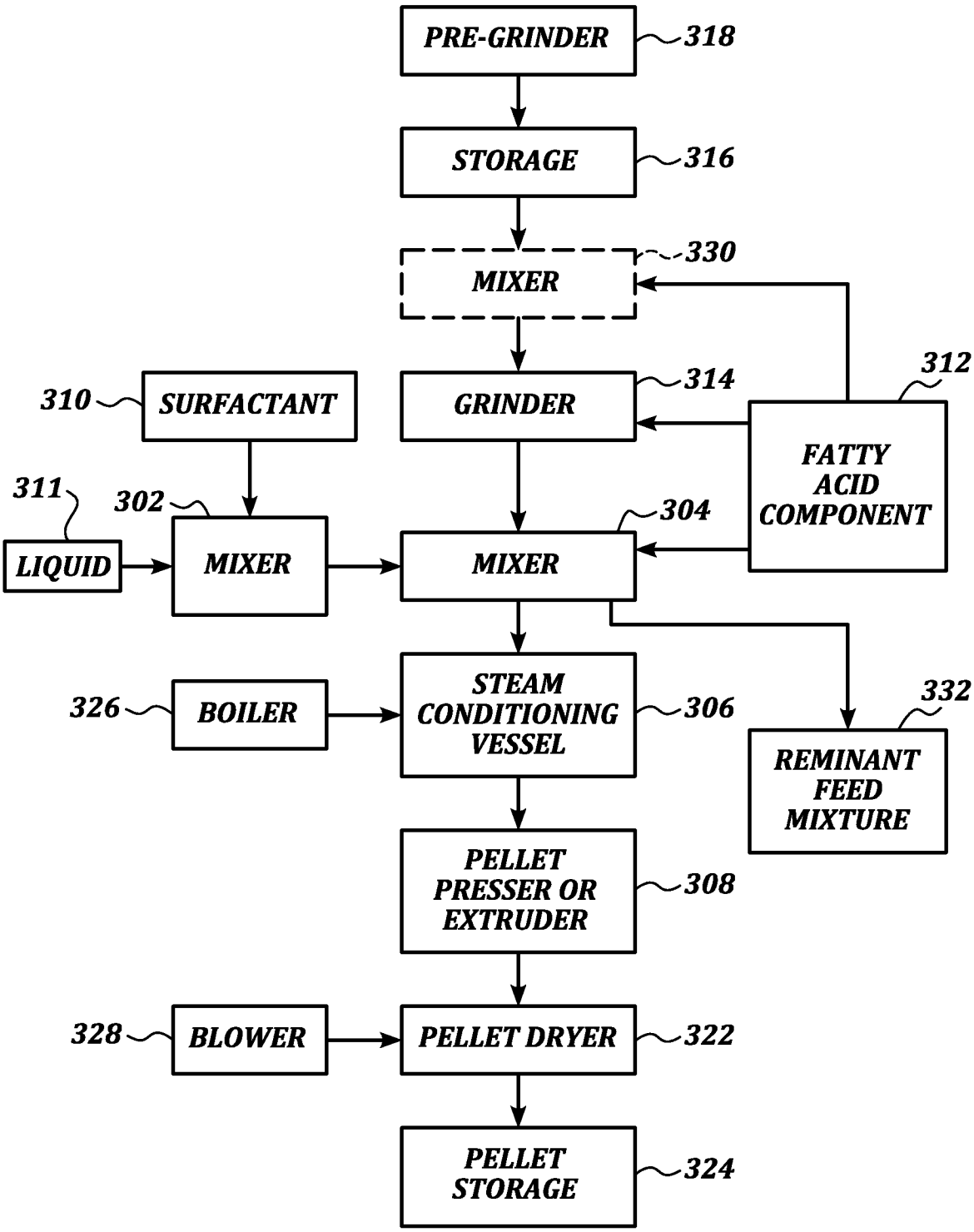
PRE-GRINDER
318
STORAGE
316
MIXER
330
GRINDER
314
312
310
SURFACTANT
FATTY ACID COMPONENT
311
302
304
LIQUID
MIXER
MIXER
326
BOILER
STEAM CONDITIONING VESSEL
306
332
REMINANT FEED MIXTURE
PELLET PRESSER OR EXTRUDER
308
328
BLOWER
PELLET DRYER
322
PELLET STORAGE
324

FIG. 3

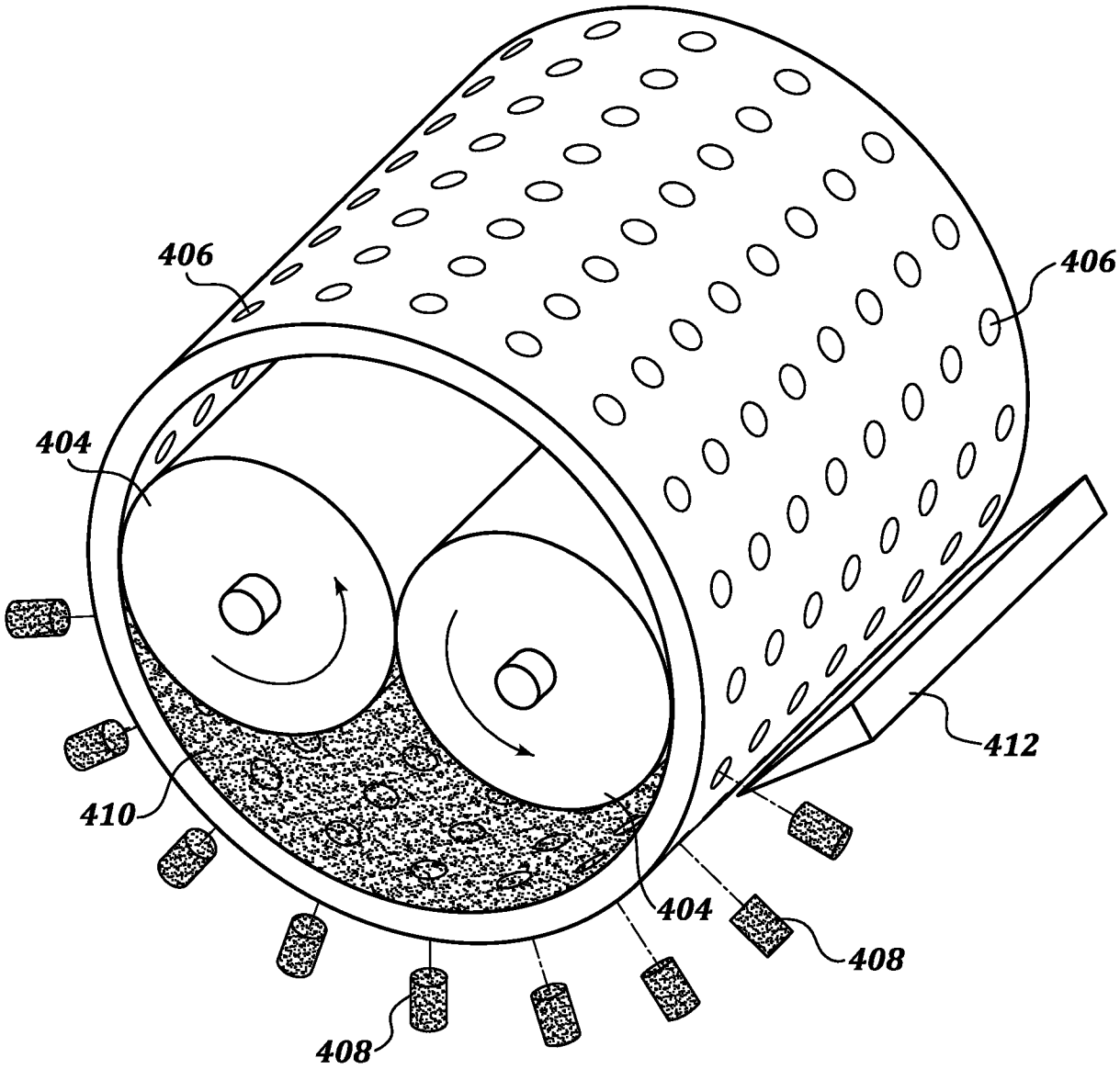

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/014116

A. CLASSIFICATION OF SUBJECT MATTER
INV. A23K1/00 A23K1/16 A23K1/18
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A23K

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, FSTA, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2013/196034 A1 (HOLMA MERJA [FI]) 1 August 2013 (2013-08-01) paragraph [0001] - paragraph [0084] examples claims -----	1-95, 102-105 96-101
X Y	US 2013/196023 A1 (HOLMA MERJA [FI]) 1 August 2013 (2013-08-01) paragraph [0001] - paragraph [0117] examples claims -----	1-95, 102-105 96-101
A	US 6 221 381 B1 (SHELFORD JAMES A [CA] ET AL) 24 April 2001 (2001-04-24) column 1, line 10 - column 7, line 28 examples 3-6 -----	1-105

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

[X] See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 May 2015	17/06/2015

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

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/014116

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/196949 A1 (WINOWISKI THOMAS STEPHEN [US]) 6 August 2009 (2009-08-06)	96-101
A	paragraph [0002] - paragraph [0035] examples figures	1-95, 102-105

Y	L Jr Tabil ET AL: "Process Conditions Affecting the Physical Quality of Alfalfa Pellets", Applied Engineering in Agriculture, 12(3), vol. 12(3) 31 December 1996 (1996-12-31), pages 345-350, XP055189363, Retrieved from the Internet: URL:http://www.researchgate.net/profile/Lope_Tabil/publication/230704609_Process_conditions_affecting_physical_quality_of_alfalfa_pellets/links/0deec52af30011ffe9000000.pdf [retrieved on 2015-05-15]	96-101
A	page 345, column 1, paragraph 1 - page 349, column 2, paragraph 1 figures tables	1-95, 102-105

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/014116

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