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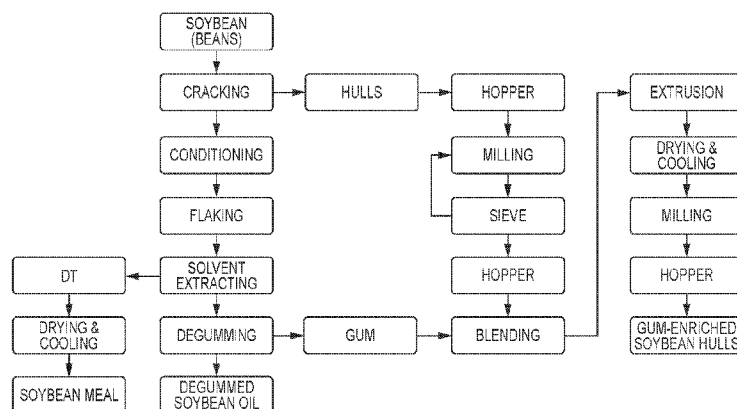


FIG. 2

(57) Abstract: Fiber energy compositions are described with one or more fibers and a gum. The gum includes phospholipids and lysophospholipids. The fiber(s) and the gum(s) are extruded to form an extrudate. The process for making the extrudate is described. The extruded product is included in animal feed to provide an enriched animal feed. Fiber energy composition with soybean hulls and soybean gum that is an extrudate is described. Animal feed supplemented with the soy fiber/soy gum extrudates are used in a method for feeding animals.

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FIBER PHOSPHOLIPID COMPOSITIONS AND METHODS OF MAKING THE SAME**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of U.S. Provisional Application No. 63/503,884, filed May 23, 2023, which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Animal health depends on several factors, and it has been appreciated that diet plays a pivotal role in health maintenance and prevention of various diseases.

[0003] Oilseeds are seeds grown primarily for the production of edible oils. Vegetable oil is obtained by pressing the seeds and then extracting the oil. The cake or meal obtained in the extraction is a rich source of proteins. Soybean, rapeseed, cottonseed, sunflower and peanut provide most of the world protein meal production.

SUMMARY

[0004] The present description provides a composition that comprises an extrudate including coextruded fiber and gum, preferably from oilseeds. The present description includes a method of blending the fiber and gum and then coextruding the fiber and gum, e.g., a gum from a degumming process, resulting in fiber energy compositions. These fiber energy compositions can provide a phospholipids-enriched feed meal source including natural choline (lecithin and/or lysolecithin), digestible fiber and fatty acids. All these components can be provided in the same composition.

[0005] The present disclosure provides a fiber energy composition comprising a fiber/gum extrudate, wherein the extrudate comprises one or more fibers and one or more gums. The gum comprises a gum from oilseeds and wherein the gum comprises phospholipids, lyso-phospholipids or combinations thereof. The present disclosure also provides the use of an extrusion process to produce a fiber energy composition.

[0006] The disclosure also provides a method to produce a fiber energy composition. The method comprises extruding one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and lyso-phospholipids.

[0007] The disclosure further provides an enriched animal feed comprising a fiber energy composition, wherein the fiber energy composition comprises a fiber/gum composition comprising one or more fibers and a gum, wherein the fiber energy composition is an extrudate,

wherein the fiber comprises soybean hulls, rice hulls and/or combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum and/or combinations thereof and wherein the gum comprises hydratable phospholipids and lyso-phospholipids

[0008] The disclosure further provides a method for feeding an animal, comprising providing a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate. The animals comprise ruminants, swine, equine, dogs, cats or any combinations thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The drawings illustrate generally, by way of example, but not by way of limitation, various aspects discussed herein.

[0010] FIG. 1 shows a schematic diagram of a flow chart illustrating an overall soybean crushing and refining flowchart for soybeans.

[0011] FIG. 2 shows a schematic diagram of a flow chart illustrating the process of generating gum-enriched soybean hulls.

[0012] FIG. 3 shows a plot that represents the body weight gain of the pigs at 21 days after the weaning (transition phase), with different inclusions of the gum-enriched soybean hulls composition of the present invention replacing similar amounts of soy hull and fat.

[0013] FIG. 4 shows a plot that represents the body weight gain of the pigs at 42 days after weaning (nursery phase), with different inclusions of the gum-enriched soybean hulls composition of the present invention replacing similar amounts of soy hull and fat.

[0014] FIG. 5 is a plot that represents the body weight gain of the pigs from 42 to 63 days after weaning (starter phase), with different inclusions of the gum-enriched soybean hulls composition of the present invention replacing similar amounts of soy hull and fat.

DETAILED DESCRIPTION

[0015] Reference will now be made in detail to certain aspects of the disclosed subject matter, examples of which are illustrated in part in the accompanying drawings. While the disclosed subject matter will be described in conjunction with the enumerated claims, it will be understood that the exemplified subject matter is not intended to limit the claims to the disclosed subject matter.

[0016] This disclosure relates to fiber energy compositions, methods of making the fiber energy compositions and using the fiber energy compositions in animal feed. The fiber energy compositions include one or more plant fibers and a plant gum. Preferably, the fibers are oilseed are a byproduct of refining crude oil from oilseeds. The gums preferably comprise lecithin and/or lysolecithin. The fiber energy composition can also include other components, e.g., sugars, protein and fatty acids. In one aspect, the present description provides a fiber energy composition comprising an extrudate wherein the extrudate is a co-extruded product of the one or more fibers and one or more gums. The fiber energy compositions described herein, surprisingly, can provide a phospholipids-enriched feed meal source of natural choline (lecithin and/or lysolecithin), digestible fiber, protein, and fatty acids. All of these components can be provided in the same composition.

[0017] In one aspect, the fiber energy composition is a soybean hulls/soybean gum fiber energy composition, referred to herein as “soy/soy fiber energy composition”. The soy/soy fiber energy composition includes an extrudate of co-extruded soybean hulls and soybean gums. The resulting soybean gum-enriched soybean hulls extrudate can be used in fiber energy compositions described herein.

[0018] In one aspect, the fiber energy composition described herein are obtained by extrusion which results in a highly stable feed meal with improved digestibility of fiber (cellulose and hemicellulose), enrichment of phospholipid content, e.g., lecithin and lysolecithin, elimination of the microorganisms, suppression of anti-nutritional components (stachyose, arabinose, urease inhibitor, etc.) and final moisture standardization. This processing which includes extrusion helps to improve quality and adds nutritional benefits for these ingredients.

[0019] The term “fiber” as used herein is the fibrous component derived from plants, for example, oilseeds. Fiber can include cellulose, hemicellulose, and lignin.

[0020] The term “gum” as used herein relates to a composition produced as a byproduct during refining of crude oils from oilseeds. Vegetable gum is a by-product from vegetable oil degumming resulting in a composition of hydratable phospholipids, triacylglycerides and water. Gums can be derived, for example, after crude oil from oilseeds is refined by a water degumming process. Gums include phospholipids, lyso-phospholipids, glycolipids and other components. Gums can include lecithin and/or lysolecithin.

[0021] The term “phospholipids” as used herein includes phospholipids and lyso-phospholipids.

[0022] The term “fiber energy composition” as used in this disclosure refers to a composition comprising gum-enriched fibers that are generated using an extrusion process with improved nutritional characteristics as described herein. The fiber energy composition may, optionally, include additional ingredients that are included either prior to extrusion, during extrusion or after extrusion.

[0023] The term “soybean hulls” as used in this disclosure refers to the fiber (hulls) from cracking and dehulling of the soybean.

[0024] The term “soybean gum” as used in this disclosure refers to the gum resulting from the degumming process of crude soybean oil. Soybean gum includes lecithin and/or lysolecithin.

[0025] The term “dry base” composition as used herein refers to a composition comprising the fiber, the gum and optionally, one or more additional ingredients prior to extrusion, e.g., prior to inclusion of moisture or added water during extrusion. Dry base composition does not include added water or steam during the extrusion process.

[0026] The designation “X”/“Y” fiber energy composition may be used herein, wherein “X” refers to the source of the fiber and “Y” refers to the source of the gum.

[0027] The term “soy/soy fiber energy composition” as used in this disclosure refers to a composition obtained by an extrusion process that combines soybean hulls and soybean gum as raw materials. The combination of soybean hulls and soybean gum that are generated using an extrusion process have improved nutritional characteristics and can be used in animal feed as additives, premixes, and/or ration for consumption by different animal species.

[0028] The term “extrudate” as used herein refers to the gum-enriched fiber composition obtained from the extrusion process described herein. The extrudate may be further processed by, for example, drying, milling and/or sieving. It will be understood that enriched animal feed and/or fiber energy compositions described herein comprise an extrudate.

[0029] The term “animal feed” as used in this disclosure refers to a composition of feed, feed components, premixes, and/or ration produced for consumption by different animal species.

[0030] The term “enriched animal feed” as used in this disclosure refers to an animal feed product comprising the fiber energy compositions described herein.

[0031] The present invention will be described in the context of using soybean hulls and soybean gums, but it will be understood other combination of hulls and gums may be used in this process and products.

[0032] The soybean is an important agricultural commodity on the world stage, being a major source of income for agribusiness. Through its processing, the soybean is used to produce various derivate ingredients, for example, to produce soybean oil, which is intended for animal or human food, or the production of biofuels. Another example of a derivate product is the soybean meal, which is the solid part of the soybean processing. The main products from the soybean oilseeds processing are soybean meal, soybean oil, soybean hulls, full fat soya and soybean specialties such as soy protein concentrate and soy protein isolate. One of the most commercialized soybean products is the so-called soybean complex – which includes the grain, the soybean oil and soybean meal.

[0033] The soybean meal and soybean oil are highly valued co-products in the oil production industry. The soybean meal comes out soon after the oil extraction with protein values higher than the guaranteed levels practiced in the market, being used as the main protein source for poultry and swine in feed formulations. To reduce protein and standardize its value according to the usual guaranteed levels, another co-product is used, which is the soybean hulls.

[0034] The soybean hull, usually commercialized in the form of pellets, appears as a good option for use in supplements and diets with a high fiber content and as another alternative in feedlot diets. However, inside the hull there are anti-nutritional components (carbohydrates and sugars) that are not used by the animal's body, that is, the animals cannot digest them and can also impair the absorption of other nutrients. Additionally, the soybean hull is not an ingredient that is commonly used in swine diets, because of the high fiber concentration and the low energy digestibility.

[0035] The refining of soybean oil for human consumption results in a series of other compounds that require correct destination for them. One of these compounds obtained during the refining of crude oil into degummed oil is the soybean gum, which is obtained by centrifuging the crude oil after it has been hydrated. Nowadays, there are basically three possible uses for the gum: 1) production of lecithin; 2) addition to soybean meal for protein standardization; and 3) lubricating additive in feed extrusion and pelleting.

[0036] The present description relates to an advantageous use of the fibers and gums with improved digestibility of hulls and other ingredients for a variety of species. The extruded gum is stable and easy to handle. The use of gum in the extrusion enhances the nutritional value of the hulls.

Fiber Sources

[0037] The fiber energy compositions described herein include one or more fibers, preferably plant fibers. The fibers are preferably from one or more oilseeds. In one aspect, the fiber energy composition can include one fiber source or a combination of two or more fiber sources. Fibers from a variety of fiber sources can be used in the fiber energy composition. Fiber sources can include, for example, soybeans, rice, corn canola, rapeseed, palm, almond, sunflower, wheat, alfalfa, sugar cane and the like. Fibers that can be included in the fiber energy composition can be, for example, soybean hulls, corn hulls, sugar cane bagasse, rice hulls, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, tomato meal, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, and grass(general). Other fiber sources and fibers may also be included and are within the scope of this description.

[0038] In one aspect, the fiber energy composition can include soybean hulls. The fiber energy composition can also include one or more other fibers as described above.

[0039] The fibers include a number of polymers and components. The fibers can include, for example, cellulose, hemicellulose, lignin, pectin, ash and the like.

[0040] In one aspect, the cellulose content in the fiber source can be between about 25wt% and about 55wt%, or preferably between 29wt% and about 51wt%, or preferably between about 30wt% and about 45wt%, or preferably between about 35wt% and about 40wt%, or preferably between about 38wt% and about 40wt% of the fiber source. Cellulose content outside of this range are also within the scope of this description.

[0041] The hemicellulose content in the fiber source can be between about 5wt% and about 25wt%, or preferably between 8wt% and about 20wt%, or preferably between about 8wt% and about 15wt%, or preferably between about 8wt% and about 12wt% of the fiber source. Hemicellulose content outside of this range are also within the scope of this description.

[0042] The lignin content in the fiber source can be between about 0.5wt% and about 10wt%, or preferably between 1wt% and about 8wt%, or preferably between about 1wt% and about 5wt%, or preferably between about 2wt% and about 5wt%, or preferably between about 2wt% and about 3wt% of the fiber source. Lignin content outside of this range are also within the scope of this description.

[0043] The pectin content in the fiber source can be between about 3wt% and about 20wt%, or preferably between 5wt% and about 18wt%, or preferably between about 6wt% and about 15wt%, or preferably between about 8wt% and about 15wt%, or preferably between about 8wt% and about 12wt%, or preferably between about 6wt% and about 12wt% of the fiber source. Pectin content outside of this range are also within the scope of this description.

[0044] The fiber source may include protein. The protein content in the soybean hulls may be between about 5wt% and about 25wt%, or preferably between 5wt% and about 20wt%, or preferably between about 9wt% and about 15wt%, or preferably between about 8wt% and about 12wt%, or preferably between about 10wt% and about 12wt%, or preferably between about 10wt% and about 11wt% of the fiber source. Protein content outside of this range are also within the scope of this description.

[0045] The ash content in the fiber source can be between about 0.5wt% and about 10wt%, or preferably between 1wt% and about 8wt%, or preferably between about 3wt% and about 7wt%, or preferably between about 4wt% and about 6wt%, or preferably between about 5wt% and about 6wt% of the fiber source. Ash content outside of this range are also within the scope of this description.

Soybean hulls (SBH)

[0046] Soybean hulls are an agricultural residue produced during processing of soybeans. The hard shell or hull of the soybean is removed mechanically and accounts for about 5–8% of bean. Soybean hulls can be a by-product of the process in which soybean oil and soybean meal are produced. Figure 1 and Figure 2 illustrate exemplary processes for generating soybean hulls from soybeans. In one exemplary process, soybeans are cracked, and the hulls are removed. Soybeans can be dehulled by a variety of process known in the art. After removal, the hulls may be heat treated and milled.

[0047] In one aspect, the soybean hulls can include cellulose, hemicellulose, lignin, pectin, protein, fat, and ash. The cellulose content in the soybean hulls can be between about 25wt% and about 55wt%, or preferably between 29wt% and about 51wt%, or preferably between about 30wt% and about 45wt%, or preferably between about 35wt% and about 40wt%, or preferably between about 38wt% and about 40wt%, or preferably about 38.4% of the soybean hulls.

[0048] The hemicellulose content in the soybean hulls can be between about 5wt% and about 25wt%, or preferably between 8wt% and about 20wt%, or preferably between about 8wt% and

about 15wt%, or preferably between about 8wt% and about 12wt%, or preferably between about 10wt% and about 11wt%, or preferably about 10.2wt% of the soybean hulls.

[0049] The lignin content in the soybean hulls can be between about 0.5wt% and about 10wt%, or preferably between 1wt% and about 8wt%, or preferably between about 1wt% and about 5wt%, or preferably between about 2wt% and about 5wt%, or preferably between about 2wt% and about 3wt%, or preferably about 2.8wt% of the soybean hulls.

[0050] The pectin content in the soybean hulls can be between about 3wt% and about 20wt%, or preferably between 5wt% and about 18wt%, or preferably between about 6wt% and about 15wt%, or preferably between about 8wt% and about 15wt%, or preferably between about 8wt% and about 12wt%, or preferably between about 6wt% and about 12wt% of the soybean hulls.

[0051] The protein content in the soybean hulls can be between about 5wt% and about 25wt%, or preferably between 5wt% and about 20wt%, or preferably between about 9wt% and about 15wt%, or preferably between about 8wt% and about 12wt%, or preferably between about 10wt% and about 12wt%, or preferably between about 10wt% and about 11wt%, or preferably about 10.7wt% of the soybean hulls.

[0052] The ash content in the soybean hulls can be between about 0.5wt% and about 10wt%, or preferably between 1wt% and about 8wt%, or preferably between about 3wt% and about 7wt%, or preferably between about 4wt% and about 6wt%, or preferably between about 5wt% and about 6wt%, or preferably about 5.8wt% of the soybean hulls.

[0053] The soybean hulls used to prepare the fiber energy composition of the present disclosure comprises for example, fiber, protein, soluble dietary fiber (FDS), and moisture. The soybean hulls can also include ethereal extract (EE) and mineral matter. The soybean hulls may comprise quality parameters that may vary. Table 1 shows an exemplary composition of the soybean hulls nutrients:

Table 1

Nutrients	Amount
Moisture (max.)	125 g/kg
Crude protein (min.)	90 g/kg
Crude fiber (max.)	400 g/kg
FDS (max.)	480 g/kg
Ethereal Extract (min.)	5000 mg/kg
Mineral matter (max.)	70 g/kg

[0054] It will be understood that the nutrient composition of the soybean hulls can vary and all soybean hulls are within the scope of this description.

Gums

[0055] Gums can include phospholipids and/or lysophospholipids. In one aspect, the gum includes hydratable phospholipids and/or lysophospholipids. Gum refers to a composition comprising different phospholipids, water and oil from a degumming process of crude oil, e.g., soybean oil. Gum from degumming process comprises water, phospholipids and oil emulsified in small micelle structure. In one aspect, the gum can comprise about 50wt%-60wt% water and about 40wt%-50wt% of phospholipids and oil. Gums with water, phospholipid and oil content outside of this range are also within the scope of this description. The amount of water, phospholipids and oil can vary based on the process set up, quality of raw material (crude oil), acidity level and the like.

[0056] The initial step of refining crude oil is a water degumming step resulting in a lipophilic fraction (degummed oil) and a more hydrophilic fraction, e.g. the gum. The gums are the non-lipophilic fraction, e.g., the more hydrophilic fraction. The lipophilic fraction is processed further to attain the refined oils. It will be understood that reference to phospholipids herein also includes lysophospholipids. The phospholipids can include lecithin and/or lysolecithin. Phospholipids are a class of lipids whose molecules contain phosphate groups (polar) and fatty acids (nonpolar). The phospholipids in the fiber energy composition can promote and/or enhance the emulsification of the fat components in the fiber energy composition. Without being bound by any theory, it is thought that enhanced emulsification properties help to increase fat digestibility of all fats present in the diets/animal feed that includes the fiber energy composition.

[0057] Degumming processes are used to remove hydrated phospholipids from crude oil during the first step of refining. This process involves the treatment of crude oils with water, a salt solution, or dilute acid such as phosphoric to remove phospholipids, waxes, and other impurities.

[0058] Water degumming is the oldest degumming treatment and forms the basis of the production of commercial lecithin, predominantly phosphatidylcholine (PC). Other phospholipids can also be present in the gum such as phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl choline (PC), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI), lyso-phosphatidylcholine (LPC) and the like. Since the water degumming process involves more water than when crude oil is allowed to absorb moisture from the atmosphere, the gums resulting from

the water degumming process also remove hydrophilic substances such as sugars from the oil. Gum is a dark and viscous liquid containing high level of water, sugars (sucrose, glucose, and fructose) resulting in low shelf life (microbiology) and excessive costs to disposal. The sugars present in the gum increase the fermentability to the detriment of the shelf life.

[0059] Gums as used herein do not include degummed oil, refined oil, soapstocks or other lipophilic fractions generated from the gums after water degumming.

[0060] The fiber energy compositions described herein can include gums from a variety of sources, preferably plant sources, e.g., oilseeds. Gums can be, for example, derived from soybeans, rapeseed, sunflower seeds, palm and the like. In one aspect, the fiber energy compositions include gums derived during refining of crude soybean oil, crude rapeseed oil, crude sunflower oil, crude palm oil and the like.

[0061] In one aspect, the fiber energy compositions described herein comprise soybean gum. The soybean gum refers to a composition comprising different phospholipids. The gums described herein can include lecithin and/or lysolecithin. Lecithin and/or lysolecithin can include, for example, phosphatidylcholine (PC), phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI), and the like. Lyso-phospholipids can include lyso-PS, lyso-PA, lyso-PC, lyso-PE, lyso-PI, and the like.

[0062] The gums described herein can also include other hydrophilic substances such as sugars from the oil. The gums can be a dark and viscous liquid containing high level of water and sugars. Sugars can include, for example, sucrose glucose, fructose and the like.

Soybean gum

[0063] The soybean gum, according to the present disclosure, comprises hydratable phospholipids resulting from degumming processes performed on crude soybean oil. The soybean gum can be a precursor of the emulsifier, lecithin. Gums from other sources may also be included in the fiber energy composition. The sugars present in the soybean gum increase the fermentability to the detriment of the shelf life. Furthermore, it is difficult to turn the soybean gum into powder due to the high energy demand to remove the water from the lecithin in conventional processes. Advantageously, the fiber energy compositions described herein incorporate the gums overcoming shelf life and energy demand issues related to water removal.

[0064] Degumming is used to remove hydrated phospholipids from crude oil during a first step of refining. Figure 1 and Figure 2 illustrate exemplary processes for generating soybean gums from soybeans and crude soybean oil. This process involves the treatment of crude oils with water,

a salt solution, or dilute acid such as phosphoric to remove phospholipids, waxes, and other impurities.

Additional Ingredients

[0065] The fiber energy composition can optionally, comprise one or more additional ingredients. Examples of additional ingredients include, but not limited to antioxidants, grains, minerals, enzymes, and other conventional additives. The grains can be selected from milled corn, ground corn, rice meal, wheat meal among other. Examples of antioxidants ingredients include, but are not limited to tertiary butyl hydroquinone (TBHQ), butylated hydroxytoluene (BHT), propyl gallate, and tocopherol, or other conventional antioxidants. An example of preferred additional ingredient is milled corn, potassium sorbate and/or tertiary butyl hydroquinone (TBHQ).

Process of making the fiber energy composition

[0066] In one aspect, the present disclosure is directed to a method of making the fiber energy compositions described herein. The method includes the use of an extrusion process to produce the fiber energy compositions. The extrusion process comprises using one or more fibers and a gum as the starting materials in an extrusion process to generate the fiber energy composition.

[0067] The use of the extrusion process surprisingly improves the digestibility (gut fermentability) of the fiber and proteins provided to the animals. The digestibility of the fiber energy composition is improved relative to a composition wherein the fiber and gums provided individually, e.g. without being subject to an extrusion process. The use of the extrusion process according to the present disclosure also surprisingly allows improved nutritional value and guaranteed homogeneity of emulsified lipids (phospholipid, fatty acids, and oil) across the fiber matrix. The extrusion significantly inhibits the action of the anti-nutritional carbohydrates present in soybean hulls and transforms them into simple molecules that can be metabolized by the animals. By the extrusion process used according to the present disclosure, the shear and temperature can allow to break up lignocellulosic components and some carbohydrates. This can facilitate metabolization, thus, increasing the number of animal species that can consume the animal feed.

[0068] The extrusion process can be generally defined as a heat treatment process for foods of HTST (High Temperature Short Time). Without being bound by any theory, it is thought that the combination of heat, humidity, and mechanical work can modify the structure of raw materials and can provide new formats with different functional and nutritional characteristics. In addition,

it is thought that the extrusion helps to bind phospholipids (gum) with the fiber structure. This can enable improved digestibility and stabilize the microbiology in the system.

[0069] Without being bound by any theory, it is thought that the fiber energy composition production process can increase the fermentability of the composition. Thus, the energy content of the fiber energy composition can be improved compared to the energy values of the raw materials e.g. the fiber, gum and the optional additional ingredients. The energy value in the fiber energy composition can be superior to the sum of the components individually.

[0070] In one aspect, the extrusion is a system that utilizes a screw to force materials through a small opening. Along the extruder, components are cooked by the high pressure, high shear, and high temperature, which is an environment created by the functioning of the screws. There are a wide variety of extruders known for food processing, whether for human consumption or for the manufacture of animal feed. The extrusion systems can comprise different components within different configurations. The extrusions systems in the methods described herein may comprise a single screw or a twin-screw extruder. Both are known in the art and can be used within the scope of this description.

[0071] In one aspect, a twin-screw extruder with interchangeable elements can be used in the process to work in conditions of low, medium, or high shear rate. In this way, high-expansion products can be developed as well as intermediate products, or pellets, without expansion, but with a degree of cooking suitable for the intended product.

[0072] In one aspect, a single screw extruder may be used. Single screw extruder equipment can have a fixed screw speed, that is, they may not have a speed regulation system. This can be improved with the incorporation of a frequency variator, allowing the screw speed control.

[0073] In one aspect, the thermoplastic extrusion is a technological process of pre-cooking or cooking of various raw materials that are derived from cereals, grains such as legumes, starches from various sources, agro-industrial co-products, etc., in which when passing through a screw (single screw or twin screw) of defined configuration inserted in a cannon or barrel with sufficient temperature in its heating zones, modify its characteristics by the heat and shear produced inside the cannon in order to gain new organoleptic characteristics, such as texture, flavor, odor and nutritional and functional properties.

[0074] The extrusion process will be described with reference to soybean hulls as a fiber source and soybean gum as a gum source, but it will be understood that other fibers or combination of fibers and other gums or any combinations of gums may be extruded as described.

[0075] The steps of an extrusion process can include, for example, (a) blending; (b) extrusion, wherein the one or more fibers and one or more gums are blended together prior to extrusion, e.g., co-extruded; (c) drying and cooling; (d) milling and sieving; and (e) storing.

[0076] In the process of the present disclosure, prior to blending step (a), the fiber source, preferably the soybean hulls, may be milled and sized. The blending step can include addition of the soybean hulls, the soybean gum and optionally, additional ingredients to a blending vessel. Additional ingredients can include starches, e.g. corn, antioxidants and the like as further described below. The blending may or may not include the addition of water. In one aspect, there is no addition of water during the blending step and/or prior to the extrusion step.

[0077] A variety of equipment and methods known in the art can be used to add the hulls and the gum to the blending vessel. Preferably, the soybean hulls may be added from a hopper into a blending vessel (dry blend or conditioner). The size of the hulls may vary between 1-10 μm , preferably 3-5 μm . The soybean gum can be in a liquid form, preferably in the pasty liquid form. Preferably, the soybean gum may be a pasty liquid that is added by droppers, pipettes or another dispenser.

[0078] Blending of the soybean hulls and the soybean gum may be conducted in a variety of vessels. Blending comprises mixing the soybean hulls, soybean gum and optionally, additional ingredients in a homogenizer. Blending may be conducted for at least 1 minute, preferably between 5 minutes and 60 minutes, or preferably between 5 minutes and 45 minutes, or preferably between 5 minutes and 30 minutes, or preferably between 5 minutes and 15 minutes, or preferably between 7 minutes and 13 minutes, or preferably between 8 and 12 minutes, or preferably about 10 minutes. Blending may be conducted at a speed of between 10 rpm and 500 rpm, or preferably between about 10 and 400rpm, or preferably between 25 and 300rpm, or preferably between 50 and 250 rpm, or preferably between 90 and 150rpm, or preferably about 100 rpm. The blending step (a) can be a continuous or a batch process. In case of a batch process, the blending step (a) may comprise the agitation time for mixing the hulls, gum, and the additional ingredients, ranging from about 1 to 60 minutes per batch, or preferably between about 1 to about 50 minutes/batch, preferably between about 1 to about 40 minutes/batch, or preferably between about 5 minutes and about 30 minutes/batch, or preferably between about 5 and 20 minutes/batch, or preferably 5 to about 15 minutes per batch, or preferably between about 8 minutes and 12 minutes/batch, or preferably 10 minutes/batch. In case of a continuous process, the rate of processing may vary and allows for mixing the soybean hulls and soybean gum in the blending vessel.

[0079] The temperature range in which the blending is conducted is between about 25-100°C, or preferably between 30-95°C, or preferably between 30-90°C, or preferably between about 40-90°C, or preferably between 40-80°C, or preferably between about 50-90°C, or preferably between about 50-80°C.

[0080] The blended mixture comprising soybean hulls, soybean gum and any optional additional ingredients are then extruded in an extrusion step (b). Thus, in one aspect, the fiber(s) and the gum(s) are combined and extruded in the extrusion step. The method may not include the addition of exogenous water during the blending of the fiber and gum. The gum may be blended with the fiber without an emulsification step. Advantageously, an emulsifying agent and/or an emulsification step are not needed prior to extrusion. Thus, an emulsion is not formed by a separate emulsion step wherein the fat and water are combined prior to blending with the fiber.

[0081] In the extrusion step (b), the blended mixture is cooked in an extruder barrel at a determined temperature and pressure. Additional ingredients desired for the fiber energy composition may be added prior to blending, during blending and/or after blending. Additional ingredients may optionally be added to the blended mixture after blending and prior to the extrusion step. Additional ingredients may optionally be added prior to the extrusion step, during the extrusion step or after the extrusion step.

[0082] The extruder used in the extrusion step comprises a variety of components including, for example, a feed silo, a conditioner, an extruder barrel with the single or twin-screw extruder, a die and cutting set. Other components may also be present and included in the scope of this disclosure. The function of the feed silo is to ensure that the dry mixture has a continuous and controlled flow of feed to the conditioner and, consequently, to the extruder barrel.

[0083] The blended mixture is passed to the conditioner. Water and/or steam may be added to the mixture in the conditioner. "Conditioning" as used herein relates to the addition of water and/or steam to the blended mixture. The temperature in the conditioner can vary and can be, for example, between 25°C and 100°C, or preferably between 30°C and 90°C, or preferably between 40°C and 90°C, or preferably between 45°C and 90°C, or preferably between 50°C and 90°C, or preferably between 50°C and 80°C. The water and steam are added to increase the temperature and moisture of the mixture, to increase the stability in the extruder and the quality of the final product.

[0084] The amount of water that may be added to the mixture in the conditioner can be at most about 50wt%, or at most about 40wt%, or at most about 30wt%, or at most about 20wt%, or at most about 10wt%. The amount of water that may be added to the mixture can be, for example,

between 0 and 50 wt.%, or preferably between 1 wt% and 40 wt%, or preferably between 2 wt.% and 30% wt, or preferably between 3 wt% and 20 wt%, or preferably between 4 wt% and 10 wt%, or preferably between 4wt% and 8wt%, or preferably 5 wt% based on the total weight of the mixture.

[0085] After leaving the conditioner, the moistened mixture passes to the extruder barrel. Temperature and pressure are crucial factors in the extrusion processing. Depending on the length of the barrel, the temperature and pressure profile must be carefully controlled in its different available zones, to avoid overcooking and/or even burning the product. The length of the barrel can vary and is dependent on the extrusion capacity. The temperature in the extruder can be between 100°C and 200°C, or preferably between 100°C and 180°C, or preferably between 100°C and 150°C, or preferably between 120°C and 200°C, or preferably between 120°C and 150°C, or preferably between 120°C and 140°C, or preferably about 130°C. The pressure in the extruder can be between 5 bar and 50 bar, or preferably between 5 bar and 40 bar, or preferably between 10 bar and 40 bar, or preferably between 10 bar and 30 bar, or preferably between 15 bar and 40 bar, or preferably between 15 bar and 30 bar, or preferably about 20 bar. The time in the extruder barrel can vary dependent on the extrusion capacity.

[0086] Without being bound by any theory, it is thought that the greatest change occurs in the fiber/gum mixture that can be partially cooked in the conditioner and can contribute to determining the final characteristics of the product. The pressure, temperature and shear inside the barrel will define the characteristics and properties of the final product.

[0087] The screw speed of the extruder comprises between 50 rpm and 500 rpm, or preferably 100 rpm and 400 rpm, or preferably 200 rpm and 400 rpm, or preferably 300 rpm and 400 rpm. The particle size in the extrusion step varies between 0.25mm to 5mm, or preferably between 0.5mm and about 5mm, or preferably between about 1.0mm and about 5mm, or preferably between about 2mm and about 5mm, or preferably between about 2mm and about 4mm, or preferably about 3mm. The temperature is as previously described, between 50°C-200°C, or preferably between 100°C and 200°C, or preferably between 110°C and 150°C, or preferably between 110°C and 140°C, or preferably between about 110°C and about 130°C, or preferably about 130°C.

[0088] The extrusion step further comprises feeding through a die and cutting the extrudate. At the end of the extruder, the die and cut occurs. The die has two functions: to restrict the output of the mixture to create the necessary pressure for the application of mechanical energy and to

change the final shape of the extrudate through the shape of the hole in the die and the cutting speed of the knives. The shape of the extrudate can vary and all are within the scope of this description. Preferably, the extrudate is a pellet.

[0089] The die comprises a diameter of between 0.25mm and 5mm, preferably 0.5mm and 4mm, more preferably between 1mm and 3mm and more preferably between 2 and 3mm and more preferably 2.5mm.

[0090] The process further comprises a drying step (c). The drying step (c) is performed to reduce the moisture of the extruded product. The moisture of the final product is less than or equal to 40%, preferably less than or equal to 30%, more preferably less than or equal to 20%, or more preferably less than or equal to 10% of the final weight of the extruded product. The moisture of the final product is between about 1wt% and about 40wt%, or preferably between about 1wt% 30wt%, or preferably between about 1wt% and about 20wt%, or preferably between about 1wt% 10wt%, or preferably between about 5wt% and about 40wt%, or preferably between about 5wt% and about 30wt%, or preferably between about 5wt% and about 20wt%, or preferably between about 5wt% and about 15wt%, or preferably between about 5wt% and about 10wt%, of the final weight of the extruded product.

[0091] The temperature during the drying step (c) can vary and can be, for example, between 70°C to 200°C, preferably between 90°C to 200°C, more preferably between 90°C to 150°C, more preferably between 90°C to 120°C, and more preferably around 110°C.

[0092] The extrusion process can be dependent on moisture, temperature and pressure. The moisture is optimized during the overall process. There is not a minimum moisture condition to start the process. The amount of water may be defined by the amount of water in the gum added to the process.

[0093] The moisture of the ingredients before feeding into the process can be between about 10wt% and 70wt.%, or preferably between about 10wt% and 60wt.%, or preferably between about 20wt% and 70wt.%, or preferably between about 20wt% and 60wt.%, or preferably between about 30wt% and 70wt.%, or preferably between about 30wt% and 60wt.%, or preferably between about 40wt% and 70wt.%, or preferably between about 40wt% and 60wt.%, or preferably between about 10wt% and 50wt.%, or preferably between about 10wt% and 40wt.%, or preferably between about 10wt% and 30wt.%, preferably between about 15wt% and 25wt%, more preferably about 18-20%. After extrusion step, the moisture of the extruded mixture is preferably at least about 5wt% or at least about 10wt%, or at least about 20wt%, or at least about 25 wt%. After extrusion step, the

moisture of the extruded mixture is preferably between about 5wt% and about 25wt%, or preferably between about 5wt% and about 20wt, or preferably between about 5wt% and about 15wt, or preferably between about 10wt% and about 25wt, or preferably between about 10wt% and about 15wt, or preferably between about 12-15%. After the drying step, the moisture of the extrudate is between about 2wt% and 20 wt%, or preferably between 2wt% and 15wt%, or preferably between 5wt% and 20wt%, or preferably between 5wt% and 15wt%, or preferably between about 8-10% to obtain adequate shelf life.

[0094] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. The particle size after the step (d) can be standardized in 0.25 - 5 mm, preferably 3 mm. After the milling step, the final product is mixed and remains stored awaiting sieving, and packing.

Fiber energy composition

[0095] In one aspect, the present disclosure comprises a fiber energy composition. The fiber energy composition can include one or more fibers as described above and one or more gums as described above. In one aspect, the fiber energy composition comprises one or more fibers and a gum. In one aspect, the fiber energy comprises one fiber and one gum. The fiber energy composition comprises an extrudate, wherein the extrudate is the product of an extrusion process. The fiber energy composition includes the one or more fibers and the one or more gums that have been modified by the extrusion process described herein.

[0096] In one aspect, the fiber energy composition comprises soybean hulls and soybean gum fiber energy composition, refer to herein as a soy/soy composition. The “fiber/gum” designation will be used herein to refer to the source of the botanical source of the fiber and the botanical source of the gum in the fiber energy composition. Thus, reference to a “soy/soy composition” is to a fiber energy composition including soybean hulls and soybean gum; a reference to a “soy/rapeseed composition” is to a fiber energy composition including soybean hulls and rapeseed gum; reference to a “soy-rice/rapeseed composition” is to a fiber energy composition including soybean hulls and rice hulls as the fiber source and rapeseed gum as the gum source. Other combinations of fiber and gum can be included with similar designations. The fiber energy composition is preferably made by a process that includes an extrusion process as described herein. Thus, the fiber energy compositions described herein are extrudates/extruded products.

[0097] The fiber energy composition comprises between about 20% by weight (wt) and 95% wt of one or more fibers, preferably between 30% wt and 90% wt, or preferably between 30%wt and 80%wt, or preferably between 40% wt and 80% wt, or preferably between 40% wt and 70% wt, or preferably between 45% wt and 95% wt, or preferably between 45% wt and 75% wt, or preferably between 45% wt and 65% wt, or preferably between 45% wt and 55% wt of one or more fibers, or preferably 50-80wt%, or preferably 50-70wt% wt, or preferably about 50wt% of one or more fibers based on the total weight of the dry base fiber energy composition.

[0098] The fiber energy composition of the present invention comprises between 5% wt and 50%wt of gum, preferably between 10% wt and 45% wt, or preferably between 15% wt and 40% wt, or preferably between 20% wt and 40% wt, or preferably between 20% wt, and 35% wt, or preferably between 25% wt and 40%wt, and or preferably between 25% wt and 35% of gum, or preferably about 30wt% of gum based on the total weight of the dry base composition.

[0099] The fiber energy composition comprises a ratio of fiber to gum between 9:1 to 1:1. Preferably, the ratio of fiber to gum is 8:1, 9:1, 6:1, 5:1, or 4:1, or 3:1, or 2:1. In one aspect, the fiber energy composition comprises 50-70% of fiber to 10-30% of gum.

[0100] In one aspect, the fiber energy composition comprises between about 20% by weight (wt) and 95% wt of soybean hulls, preferably between 30% wt and 90% wt, or preferably between 30%wt and 80%wt, or preferably between 40% wt and 80% wt, or preferably between 40% wt and 70% wt, or preferably between 45% wt and 95% wt, or preferably between 45% wt and 75% wt, or preferably between 45% wt and 65% wt, or preferably between 45% wt and 55% wt of soybean hulls, or preferably about 50wt% of soybean hulls based on the total weight of the dry base fiber energy composition. The fiber energy composition comprises between 5% wt and 50%wt of soybean gum, preferably between 10% wt and 45% wt, or preferably between 15% wt and 40% wt, or preferably between 20% wt and 40% wt, or preferably between 20% wt, and 35% wt, or preferably between 25% wt and 40%wt, and or preferably between 25% wt and 35% of soybean gum, or preferably about 30wt% of soybean gum based on the total weight of the dry base composition.

[0101] The fiber energy composition may, optionally, comprise one or more additional ingredients. The additional ingredients, e.g. the ground corn, may assist in the extrusion of the fiber and the gum and may assist in the integrity of pellet formation. Fiber energy composition without the inclusion of grains/starches during the extrusion process are also within the scope of this description. The one or more additional ingredients can be between 0% wt and 40% wt,

preferably between 5% wt and 30% wt, or preferably between 10% wt and 40% wt, or preferably between 10% wt and 30% wt, or preferably between 15% wt and 25% wt, or preferably about 20wt% based on the total weight of the dry base fiber energy composition. Examples of additional ingredients include, but not limited to antioxidants, grains, minerals, enzymes, and other conventional additives. The grains can include a number of starch sources and can be, for example, milled corn, ground corn, rice meal, wheat meal among other. Examples of antioxidants ingredients include but are not limited to tertiary butyl hydroquinone (TBHQ), butylated hydroxytoluene (BHT), propyl gallate, potassium sorbate and tocopherol, or other conventional antioxidants. An example of preferred additional ingredient is ground corn and/or tertiary butyl hydroquinone (TBHQ).

[0102] In one aspect, the fiber energy composition can additionally comprise corn, preferably ground corn as an additional ingredient. The ground corn can be between 0% wt and 40% wt, preferably between 5% wt and 30% wt, or preferably between 10% wt and 40% wt, or preferably between 10% wt and 30% wt, or preferably between 15% wt and 25% wt, or preferably about 20wt% based on the total weight of the dry base fiber energy composition.

[0103] In one aspect, the fiber energy composition comprises between 40% wt and 60% wt of soybean hulls based on the total weight of the dry base composition and preferably between 20% wt and 40% wt of gum based on the total weight of the dry base composition, between 0 %wt and 30 wt%, preferably between 10wt% and 30wt% of milled corn based on the total weight of the dry base composition and between about 0,5% wt and 1 % wt of TBHQ based on the total weight of the dry base composition.

[0104] In one aspect, the fiber energy composition comprises 60-90wt% of soybean hulls and 10-30wt% of soybean gum and 0 to 30wt% ground corn or other starch source. In one aspect, the fiber energy composition comprises 60wt% of soybean hulls, 10wt% of soybean gum and about 30wt% of ground corn. In one aspect, the fiber energy composition comprises 50wt% of soybean hulls, 30wt% of soybean gum and about 20wt% of ground corn. In one aspect, the fiber energy composition comprises 90wt% of soybean hulls and 10wt% of soybean gum. In one aspect, the fiber energy composition comprises 70wt% of soybean hulls and 30wt% of soybean gum. The fiber energy compositions without a starch source are within the scope of this description.

[0105] The fiber energy composition made by the extrusion process of the present disclosure helps to improve animal performance (energy source), animal health (prebiotic effects) and add nutritional value at co-product feedstock from soybean crushing (hulls and gum). This fiber energy

composition can be used to feed a vast number of animal species aiming to improve conversion and growth.

[0106] A nutritional value of a raw material is not limited to its chemical composition (protein, energy, fiber and mineral values). As mentioned in the disclosure herein, there are raw materials of greater or lesser digestibility (greater or lesser ease of breaking down their constituents) and the presence of anti-nutritional compounds (compounds naturally present in foods that will make their digestibility difficult). This relative digestibility of each raw material may also vary according to the species of animal.

[0107] The anti-nutritional factors themselves are substances that, even in a vestigial state, reduce or completely prevent the use of a nutritional element by the animal (both at the digestive level and at the metabolic level). Known anti-nutritional factors: antivitamin, organic acids that chelate mineral cations, antienzymes (such as soy antitrypsin), condensed tannins (present in sorghum grains), lectins, saponins (quinoa).

[0108] The digestibility of the fiber energy composition can improve when made with the process described herein. In one aspect, the digestibility of the fiber energy composition can improve by between 1% and 95% relative to the unextruded, blended mixture of fiber and gum, preferably between 5% and 80%, preferably between 10% and 70%, more preferably between 5% and 60%, more preferably between 5% and 50%, more preferably between 10% and 40% more preferably between 10% and 30% and more preferably between 15% and 25%.

Enriched animal feed

[0109] In one aspect, the present invention includes a method of feeding animals. The method includes providing to the animal, an enriched animal feed comprising the fiber energy compositions of the present disclosure.

[0110] The inclusion of the fiber energy composition made by the extrusion process of the present disclosure with the animal feed helps to improve animal performance (energy source), animal health (prebiotic effects) and add nutritional value at co-product feedstock from soybean crushing (hulls and gum). This fiber energy composition can be used to feed a number of animal species aiming to improve conversion and growth.

[0111] In one aspect, the enriched animal feed comprises the fiber energy composition. The fiber energy composition can be the extrudate/extruded product. The fiber energy composition is intended for feeding a wide range of animal species. Therefore, the term “animals” as used in this disclosure includes, but not limited to, ruminants and monogastric animals. Preferably, the fiber

energy composition may be directly fed to the animal, or preferably, the fiber energy composition may be combined with animal feed to generate an enriched animal feed that is fed to the animals. [0112] In one aspect, the enriched animal feed comprises the fiber energy composition described herein, for example, the soy/soy composition, together with any conventional ingredients commonly used in animal feed, for instance, grains, protein sources, synthetic amino acids, vitamins, minerals, enzymes, flavorings, among others. Animal feed can also include additives, for example, mycotoxin binders, essential oils, organic acids, phytogenics and the like. Animal feed as used herein can include animal feed premixes, rations and other feed for different animal species may also be supplemented with the fiber energy composition described herein. The inclusion rates described herein relate to the final inclusion rate present in the animal feed provided to the animal. Thus, a premix may have a higher content of the fiber energy composition that will be diluted upon combining with other ingredients to form the animal feed with the fiber energy composition at the inclusion rates described below.

[0113] The fiber energy composition can be provided with the animal feed. The fiber energy feed may be blended, provided as top dressing, or combined in other methods known in the art with the animals to generate the enriched animal feed. The fiber energy composition described herein can be provided in the animal feed at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of animal feed. The fiber energy composition described herein can be provided in the animal feed at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the animal feed.

[0114] The enriched animal feed can include the fiber energy composition at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of enriched animal feed. The enriched animal feed can include the fiber energy composition at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the enriched animal feed.

Method of feeding animals

[0115] The fiber energy composition can be provided to a variety of animals. The animals may be monogastric animals or ruminants. Monogastric animals provided the fiber energy composition can include swine, equine, and pets, e.g., dogs, cats. The fiber energy composition may be provided by combining the fiber energy composition with an animal feed, animal feed premix and the like. Providing the fiber energy composition using other methods is also within the scope of this description. Feeding will be described in the context of providing enriched animal feed that includes the fiber energy composition, but it will be understood that the fiber energy composition may be provided directly to the animal.

[0116] The enriched animal feed comprising the fiber energy composition may be fed to an animal one or more times per day, preferably two or more times per day, more preferably three or more times per day. The enriched animal feed may be fed to an animal one to five times a day, preferably two to four times a day, preferably three times a day. The fiber energy composition may be fed to the animal at every feeding. The fiber energy composition may be provided to the animals at all phases of development, preferably after weaning. Prior to weaning, the young animals may benefit from the fiber energy composition provided to the lactating animal.

Swine

Enriched swine feed

[0117] In one aspect, the present invention includes a method of feeding swine. The method includes providing swine with an enriched swine feed comprising the fiber energy compositions of the present disclosure.

[0118] In one aspect, the enriched swine feed comprises the fiber energy composition. The fiber energy composition can be the extrudate/extruded product. The fiber energy composition is intended for feeding all swine including, for example, piglets, sows. Preferably, the fiber energy composition may be directly fed to the swine, or preferably, the fiber energy composition may be combined with swine feed to generate an enriched swine feed that is fed to the swine.

[0119] In one aspect, the fiber energy composition for swine comprises between 40% wt and 95% wt of fiber, e.g., soybean hulls, based on the total weight of the dry base composition, or preferably between about 45wt% and about 85wt%, or preferably between about 45wt% and about 75wt%, or preferably between about 45wt% and 65wt%, or preferably between about 45wt% and about 55wt%, or preferably about 50wt%. The fiber can be one or more of the following fibers: soy hulls, corn, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay,

soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, tomato meal, rice hulls and palm kernel expellers.

[0120] The fiber energy composition for swine comprises between 5% wt and 50% wt of gum, e.g., soybean gum, based on the total weight of the dry base composition, or preferably between about 10wt% and about 50wt%, or preferably between about 20wt% and about 50wt%, or preferably between about 20wt% and 40wt%, or preferably between about 25wt% and about 35wt%, or preferably about 30wt%. The gum may be one or more of the following gums: soybean gum, rapeseed gum, sunflower gum.

[0121] The fiber energy composition for swine comprises between 0% wt and 25% wt of starch, e.g., milled corn, wheat, etc., based on the total weight of the dry base composition, or preferably between about 5wt% and about 25wt%, or preferably between about 5wt% and about 20wt%, or preferably between about 10wt% and 25wt%, or preferably between about 15wt% and about 25wt%, or preferably about 20wt%.

[0122] In one aspect, the enriched swine feed comprises the fiber energy composition described herein, for example, the soy/soy composition, together with any conventional ingredients commonly used in swine feed, for instance, grains, protein sources, synthetic amino acids, vitamins, minerals, enzymes, flavorings, among others. Animal feed can also include additives, for example, mycotoxin binders, essential oils, organic acids, phytogenics and the like. Swine feed as used herein can include swine feed premixes, rations and other feed may also be supplemented with the fiber energy composition described herein. The inclusion rates described herein relate to the final inclusion rate present in the swine feed provided to the swine. Thus, a premix may have a higher content of the fiber energy composition that will be diluted upon combining with other ingredients to form the swine feed with the fiber energy composition at inclusion rates described herein.

[0123] The fiber energy composition can be provided with the swine feed. The fiber energy feed may be blended, provided as top dressing, or combined in other methods known in the art. The fiber energy composition described herein can be provided in the swine feed at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of swine feed. The fiber energy composition described herein can be provided in the swine feed at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or

preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the swine feed.

[0124] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. The particle size after the step (d) can be standardized in 0.25 - 5 mm, preferably 3 mm. After the milling step, the final product is mixed and remains stored awaiting sieving, and packing.

[0125] The enriched swine feed can include the fiber energy composition at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of enriched swine feed. The enriched swine feed can include the fiber energy composition at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the enriched swine feed.

[0126] The present description includes a method of feeding a monogastric animal, preferably a swine (*Sus domesticus*). In one aspect, swine can be a piglet, neonatal piglets and/or post-weaning piglets. Swine can be breeders. Swine can be gestational sows and/or lactation sows. Sows can include gilts (first parity) and multiparous sows. Swine can be hog finishers. The method of feeding swine will be discussed with reference to piglets and sows but it will be understood that all swine may be provided the fiber energy compositions as described herein.

[0127] In one aspect, the method of feeding swine can include providing the fiber energy composition, preferably the soy/soy composition, described herein to swine at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 3wt% and 15wt%, or preferably between 5wt% and 10wt%, or preferably between about 5wt% and about 7.5 wt% of the enriched animal feed.

[0128] The method further includes feeding swine, preferably piglets and/or sows, one or more times per day, preferably two or more times per day, or preferably three or more times per day. The method includes providing the fiber energy composition with at least one feeding, or preferably with at least two feedings, or preferably with every feeding.

A. Piglets

[0129] Considering the pig production chain, it is divided into phases, each of which has different nutritional requirements, which are mainly influenced by the genetic potential of the animals and age. The productive phases of pigs are divided into 4 stages: breastfeeding (0-28 days), nursery (28-63 days), growth (63-105 days) and finishing (105-140 days). Each cycle follows a calendar of days, where the diet is formulated according to nutritional requirements.

[0130] In one aspect, the method of feeding a piglet can include providing the fiber energy composition described herein at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 3wt% and 15wt%, or preferably between 5wt% to 10wt%, or preferably between about 5wt% about 7.5 wt% in the animal feed.

[0131] In one aspect, the method of feeding a piglet can include providing an enriched animal feed, wherein the enriched animal feed comprises a basal diet feed and the fiber energy composition. The enriched animal feed comprises the fiber energy composition described herein at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 2wt% and 13wt%, or preferably between about 2wt% up 10 wt%, or preferably between about 2wt% and 8wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 5wt% and 15wt%, or preferably between about 5wt% up 13 wt%, or preferably between about 5wt% and 10wt%, or preferably between 5wt% to 8wt%, or preferably between about 5wt% about 7.5 wt%, or about 7.5wt% of the enriched animal feed.

[0132] In one aspect, the method of feeding a piglet comprises providing the fiber energy composition at an amount between about 3.0g/piglet/day and about 100g/piglet/day, or preferably between about 7g/piglet/day and 90g/piglet/day, or preferably between about 15g/piglet/day and 85g/piglet/day, or preferably between about 20g/piglet/day and 80g/piglet/day, or preferably between about 20g/piglet/day and 70g/piglet/day, or preferably between about 20g/piglet/day and 60g/piglet/day, or preferably between about 20g/piglet/day and 50g/piglet/day, or preferably between about 30g/piglet/day and 85g/piglet/day, or preferably between about 30g/piglet/day and 80g/piglet/day, or preferably between about 30g/piglet/day and 70g/piglet/day, or preferably between about 30g/piglet/day and 60g/piglet/day, or preferably between about 40g/piglet/day and 80g/piglet/day, or preferably between about 40g/piglet/day and 70g/piglet/day, or preferably between about 40g/piglet/day and 60g/piglet/day, or preferably between about 40g/piglet/day and 50g/piglet/day, or preferably between about 45g/piglet/day and 55g/piglet/day. These amounts are based on the average piglet body weight of about 16kg from weaning to 63 days of age and with average feed intake in the period of about 650g/day.

[0133] The method includes providing the fiber energy composition post-weaning, e.g., during the nursery phase and/or the growth phase. Preferably, the method includes providing the fiber energy composition to the piglets during the nursery phase, e.g., between about days 21 and days 63 of the piglet's life. The fiber energy composition may also be provided during the growth phase, e.g., days 63-105. The method of feeding the piglets according to the methods described herein may increase the weight gain of the piglets by at least 2%, preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to weight gain without the inclusion of the fiber energy composition. The weight gain can be between 2% and 10%, preferably 3% and 8%, more preferably 5% and 8% relative to weight gain without the inclusion of the fiber energy composition. The method of feeding the piglet can improve the energy metabolism by emulsification of lipids, allows improvement of pelletization runability (lubricant effects), allows increasing production while decreasing energy consumption.

[0134] In one aspect, providing the fiber energy composition to an animal, e.g. piglets, increases the weight gain by at least 2%, preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to weight gain without the inclusion of the fiber energy composition. The weight gain can be between 2% and 10%, preferably 3% and 8%, more preferably 5% and 8% relative to weight gain without the inclusion of the fiber energy composition. The consumption of the fiber energy composition can improve the energy metabolism by emulsification of lipids, allows improvement of pelletization runability (lubricant effects), allows increasing production while decreasing energy consumption.

B. Sows

[0135] In one aspect, the method of feeding a sow, preferably a lactating sow. The sow can be a gilt or multiparous. The method can include providing the fiber energy composition described herein to the sow at an inclusion rate of at least 2wt%, or at least 3wt%, or at least 5wt%. The method can include providing the fiber energy composition described herein to the sow at an inclusion rate of between 2wt% up 15 wt%, preferably between 3wt to 8wt%, more preferably between about 4 to about 7.5 wt% of the enriched animal feed. The method further includes feeding the sows one or more times per day, preferably two or more times per day, more preferably three or more times per day. The method includes providing the fiber energy composition with at least one feeding, or preferably with at least two feedings, or more preferably with every feeding.

[0136] In one aspect, the method includes providing the fiber energy composition during the lactation phase of the sow. The lactation phase can be between farrowing and up to weaning of

the piglets, preferably day 1 after farrow to until the piglets are weaned. The fiber energy composition may be provided starting about a few days, about 1-10 days before farrowing and continued until weaning. In one aspect, the fiber energy composition may be provided to the sows from day 1 after farrowing to about day 20 after farrowing, preferably between day 1 and day 25 after farrowing, and day 1 and day 30 after farrowing. In one aspect, the fiber energy composition is provided to the sows for at least 10 days, or at least 15 days, or at least 20 days, or at least 25 days.

[0137] In one aspect, the method of feeding a piglet comprises providing the fiber energy composition at an amount between about 50g/sow/day and about 1000g/sow/day, or preferably between about 100g/sow/day and 900g/sow/day, or preferably between about 100g/sow/day and 800g/sow/day, or preferably between about 100g/sow/day and 700g/sow/day, or preferably between about 100g/sow/day and 600g/sow/day, or preferably between about 100g/sow/day and 500g/sow/day, or preferably between about 100g/sow/day and 400g/sow/day, or preferably between about 200g/sow/day and 800g/sow/day, or preferably between about 200g/sow/day and 700g/sow/day, or preferably between about 200g/sow/day and 600g/sow/day, or preferably between about 200g/sow/day and 500g/sow/day, or preferably between about 200g/sow/day and 400g/sow/day, or preferably between about 300g/sow/day and 800g/sow/day, or preferably between about 300g/sow/day and 700g/sow/day, or preferably between about 300g/sow/day and 600g/sow/day, or preferably between about 300g/sow/day and 500g/sow/day, or preferably between about 300g/sow/day and 400g/sow/day. These amounts are based on the average sow body weight from farrow to weaning of about 234kg with average feed intake in the period of about 6.7kg/sow/day.

[0138] In one aspect, the method may include providing the fiber energy composition during the gestational phase of the sow. The gestation phase can be from insemination until farrowing. The fiber energy composition may also be provided prior to insemination to prepare the sow for insemination. The fiber energy composition may be provided for at least a week, or at least two weeks prior to insemination. The method of providing the fiber energy composition to the gestational sows can improve the performance of the piglets in the litter.

[0139] The method of feeding the lactating sows may increase the weaning weight of the piglets in the litter by at least 2%, or preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to weaning weight without the inclusion of the fiber energy composition but equivalent energy content.

[0140] The method of feeding the sows, e.g., lactating sows, may increase the body weight gain/piglet by at least 2%, or preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to the body weight gain/piglet without the inclusion of the fiber energy composition but equivalent energy content.

[0141] The method of feeding the sows, e.g., lactating sows, may increase the average daily gain (ADG) by the piglets by at least 2%, or preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to the ADG of the piglets without the inclusion of the fiber energy composition but equivalent energy content.

[0142] The method of feeding the sows, e.g., lactating sows, may increase the litter ADG by at least 2%, or preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to the litter ADG of the piglets without the inclusion of the fiber energy composition but equivalent energy content.

[0143] The method of feeding the sows, e.g., lactating sows, may increase the birth weight of the piglets by at least 2%, or preferably by at least 3%, more preferably about 4%, more preferably about 5%, preferably by 10% relative to the birth weight of the piglets without the inclusion of the fiber energy composition but equivalent energy content.

Ruminants

[0144] In one aspect, the present invention includes a method of feeding ruminants. The method includes providing ruminants with an enriched ruminant feed comprising the fiber energy compositions of the present disclosure.

[0145] In one aspect, the enriched ruminant feed comprises the fiber energy composition. The fiber energy composition can be the extrudate/extruded product. The fiber energy composition is intended for feeding all ruminants. Preferably, the fiber energy composition may be directly fed to the ruminant, or preferably, the fiber energy composition may be combined with ruminant feed to generate an enriched ruminant feed that is fed to the ruminant.

[0146] In one aspect, the fiber energy composition for ruminant comprises between 40% wt and 95% wt of fiber, e.g., soybean hulls, based on the total weight of the dry base composition, or preferably between about 45wt% and about 85wt%, or preferably between about 45wt% and about 75wt%, or preferably between about 45wt% and 65wt%, or preferably between about 45wt% and about 55wt%, or preferably about 50wt%. The fiber can be one or more of the following fibers: soy hulls, corn, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay,

soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, tomato meal, rice hulls and palm kernel expellers.

[0147] The fiber energy composition for ruminant comprises between 5% wt and 50% wt of gum, e.g., soybean gum, based on the total weight of the dry base composition, or preferably between about 10wt% and about 50wt%, or preferably between about 20wt% and about 50wt%, or preferably between about 20wt% and 40wt%, or preferably between about 25wt% and about 35wt%, or preferably about 30wt%. The gum may be one or more of the following sources: soybean, rapeseed, sunflower, coconut, palm, refined palm olein, rice bran and the like.

[0148] The fiber energy composition for ruminant comprises between 0% wt and 25% wt of starch, e.g., milled corn, wheat, barley, sorghum etc., based on the total weight of the dry base composition, or preferably between about 5wt% and about 25wt%, or preferably between about 5wt% and about 20wt%, or preferably between about 10wt% and 25wt%, or preferably between about 15wt% and about 25wt%, or preferably about 20wt%.

[0149] In one aspect, the enriched ruminant feed comprises the fiber energy composition described herein, for example, the soy/soy composition, together with any conventional ingredients commonly used in ruminant feed, for instance, vitamins, minerals, enzymes, flavorings, among others. Ruminant feed as used herein can include ruminant feed premixes, rations and other feed may also be supplemented with the fiber energy composition described herein. The inclusion rates described herein relate to the final inclusion rate present in the ruminant feed provided to the ruminant. Thus, a premix may have a higher content of the fiber energy composition that will be diluted upon combining with other ingredients to form the ruminant feed.

[0150] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. After the milling step, the final product can be a meal (powder), pellet, liquid and the like.

[0151] The fiber energy composition can be provided with the ruminant feed. The fiber energy feed may be blended, provided as top dressing, or combined in other methods known in the art. The fiber energy composition described herein can be provided in the ruminant feed at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of ruminant feed. The fiber energy composition described herein can be provided in the ruminant feed at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between

4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the ruminant feed.

[0152] The enriched ruminant feed can include the fiber energy composition at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of enriched ruminant feed. The enriched ruminant feed can include the fiber energy composition at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the enriched ruminant feed.

[0153] The present description includes a method of feeding a multi-gastric animal, preferably a ruminant. In one aspect, the method of feeding ruminant can include providing the fiber energy composition, preferably the soy/soy composition, described herein to ruminant at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 3wt% and 15wt%, or preferably between 5wt% and 10wt%, or preferably between about 5wt% and about 7.5 wt% of the enriched animal feed.

[0154] The method further includes feeding ruminant one or more times per day, preferably two or more times per day, or preferably three or more times per day. The method includes providing the fiber energy composition with at least one feeding, or preferably with at least two feedings, or preferably with every feeding.

[0155] Equine

[0156] In one aspect, the present invention includes a method of feeding equine. The method includes providing equine with an enriched equine feed comprising the fiber energy compositions of the present disclosure.

[0157] In one aspect, the enriched equine feed comprises the fiber energy composition. The fiber energy composition can be the extrudate/extruded product. The fiber energy composition is intended for feeding all equine. Preferably, the fiber energy composition may be directly fed to the equine, or preferably, the fiber energy composition may be combined with equine feed to generate an enriched equine feed that is fed to the equine.

[0158] In one aspect, the fiber energy composition for equine comprises between 40% wt and 95% wt of fiber, e.g., soybean hulls, based on the total weight of the dry base composition, or

preferably between about 45wt% and about 85wt%, or preferably between about 45wt% and about 75wt%, or preferably between about 45wt% and 65wt. The fiber can be one or more of the following fibers: soy hulls, rice hulls, wheat midds, peanut hulls.

[0159] The fiber energy composition for equine comprises between 5% wt and 50% wt of gum, e.g., soybean gum, based on the total weight of the dry base composition, or preferably between about 10wt% and about 50wt%, or preferably between about 20wt% and about 50wt%, or preferably between about 20wt% and 40wt%, or preferably between about 25wt% and about 35wt%, or preferably about 30wt%.

[0160] The fiber energy composition for equine comprises between 0% wt and 25% wt of starch, e.g., milled corn, wheat bran, ddg, oat, etc., based on the total weight of the dry base composition, or preferably between about 5wt% and about 25wt%, or preferably between about 5wt% and about 20wt%, or preferably between about 10wt% and 25wt%, or preferably between about 5wt% and about 15wt%, or preferably between about 0wt% and about 20wt%.

[0161] In one aspect, the enriched equine feed comprises the fiber energy composition described herein, for example, the soy/soy composition, together with any conventional ingredients commonly used in equine feed, for instance, vitamins, minerals, enzymes, flavorings, among others. Equine feed as used herein can include equine feed premixes, rations and other feed may also be supplemented with the fiber energy composition described herein. The inclusion rates described herein relate to the final inclusion rate present in the equine feed provided to the equine. Thus, a premix may have a higher content of the fiber energy composition that will be diluted upon combining with other ingredients to form the equine feed.

[0162] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. After the milling step, the final product can be pellet, extruded nuggets and the like.

[0163] The fiber energy composition can be provided with the equine feed. The fiber energy feed may be blended, provided as top dressing, or combined in other methods known in the art. The fiber energy composition described herein can be provided in the equine feed at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of equine feed. The fiber energy composition described herein can be provided in the equine feed at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between

4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the equine feed.

[0164] The enriched equine feed can include the fiber energy composition at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of enriched equine feed. The enriched equine feed can include the fiber energy composition at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the enriched equine feed.

[0165] The present description includes a method of feeding a monogastric animal, preferably an equine. In one aspect, the method of feeding equine can include providing the fiber energy composition, preferably the soy/soy composition, described herein to equine at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 3wt% and 15wt%, or preferably between 4wt% and 12wt%, or preferably between 5wt% and 10wt%, or preferably between about 5wt% and about 7.5 wt% of the enriched animal feed.

[0166] In one aspect, the present description includes a method of providing a fiber energy composition to a equine, at an amount of between about 600g/horse/day and about 3500g/horse/day, or preferably between about 700g/horse/day and about 3000g/horse/day, or preferably between about 700g/horse/day and about 2500g/horse/day, or preferably between about 700g/horse/day and about 2000g/horse/day, or preferably between about 700g/horse/day and about 1500g/horse/day, or preferably between about 700g/horse/day and about 1000g/horse/day, or preferably between about 1000g/horse/day and about 3000g/horse/day, or preferably between about 1000g/horse/day and about 2500g/horse/day, or preferably between about 1000g/horse/day and about 2000g/horse/day, or preferably between about 1000g/horse/day and about 1500g/horse/day, or preferably between about 1500g/horse/day and about 2500g/horse/day, or preferably between about 1500g/horse/day and about 2000g/horse/day.

[0167] The method further includes feeding equine one or more times per day, preferably two or more times per day, or preferably three or more times per day. The method includes providing

the fiber energy composition with at least one feeding, or preferably with at least two feedings, or preferably with every feeding.

[0168] **Pets**

[0169] In one aspect, the present invention includes a method of feeding pets. Pets can include dogs, cats and the like. The method includes providing pets with an enriched pet food comprising the fiber energy compositions of the present disclosure.

[0170] In one aspect, the enriched pet food comprises the fiber energy composition. The fiber energy composition can be the extrudate/extruded product. The fiber energy composition is intended for feeding all pets. Preferably, the fiber energy composition may be directly fed to the pets, or preferably, the fiber energy composition may be combined with pet food to generate an enriched pet food that is fed to the pets.

[0171] In one aspect, the fiber energy composition for pets comprises between 40% wt and 95% wt of fiber, e.g., soybean hulls, based on the total weight of the dry base composition, or preferably between about 45wt% and about 85wt%, or preferably between about 45wt% and about 75wt%, or preferably between about 45wt% and 65wt%, or preferably between about 45wt% and about 55wt%, or preferably about 50wt%. The fiber can be one or more of the following fibers: soybean meal, canola meal, wheat bran, wheat middlings, alfalfa, sunflower meal, beet pulp, citrus pulp, tomato pomace, rice hulls, oat groats, cellulose, fructooligosaccharides, mannonoligosaccharides, inulin, dried vegetables, dried fruit, pumpkin, sweet potatoes, white potatoes.

[0172] The fiber energy composition for pets comprises between 5% wt and 50% wt of gum, e.g., soybean gum, based on the total weight of the dry base composition, or preferably between about 10wt% and about 50wt%, or preferably between about 20wt% and about 50wt%, or preferably between about 20wt% and 40wt%, or preferably between about 25wt% and about 35wt%, or preferably about 30wt%. The gum may be one or more of the following sources: soybean, sunflower, canola, coconut, flax seed, and the like.

[0173] The fiber energy composition for pets comprises between 0% wt and 25% wt of starch, e.g., corn, wheat, white rice, brown rice, sweet potatoes, potatoes, etc., based on the total weight of the dry base composition, or preferably between about 5wt% and about 25wt%, or preferably between about 5wt% and about 20wt%, or preferably between about 10wt% and 25wt%, or preferably between about 15wt% and about 25wt%, or preferably about 20wt%.

[0174] In one aspect, the enriched pet food comprises the fiber energy composition described herein, for example, the soy/soy composition, together with any conventional ingredients commonly used in pet food, for instance, vitamins, minerals, enzymes, flavorings, among others. Pet food as used herein can include pet food premixes, rations and other feed may also be supplemented with the fiber energy composition described herein. The inclusion rates described herein relate to the final inclusion rate present in the pet food provided to the pets. Thus, a premix may have a higher content of the fiber energy composition that will be diluted upon combining with other ingredients to form the pet food.

[0175] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. After the milling step, the final product can be a meal (powder), pellet, kibble, liquid and the like.

[0176] The fiber energy composition can be provided with the pet food. The fiber energy feed may be blended, provided as top dressing, or combined in other methods known in the art. The fiber energy composition described herein can be provided in the pet food at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of pet food. The fiber energy composition described herein can be provided in the pet food at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the pet food.

[0177] The enriched pet food can include the fiber energy composition at an inclusion rate of at least 2wt%, or at least 5 wt% or at least 10wt%, or at least 20wt%, based on the weight of enriched pet food. The enriched pet food can include the fiber energy composition at an inclusion rate of between 2wt% up 15 wt%, or preferably between 3wt% to 12wt%, or preferably between 3wt% to 10wt%, or preferably between 4wt% to 12wt%, or preferably between 4wt% to 10wt%, or preferably between 3wt% to 8wt%, or preferably between 4wt% to 8wt%, or preferably between 5wt% and 10wt%, or preferably between 5wt% and 8wt% based on the weight of the enriched pet food.

[0178] The present description includes a method of feeding a monogastric animal, preferably a pet. In one aspect, the method of feeding pets can include providing the fiber energy

composition, preferably the soy/soy composition, described herein to pets at an inclusion rate of between 1wt% and 20wt%, or preferably between about 2wt% up 15 wt%, or preferably between about 3wt% and 15wt%, or preferably between 5wt% and 10wt%, or preferably between about 5wt% and about 7.5 wt% of the enriched animal feed.

[0179] In one aspect, the present description includes a method of providing a fiber energy composition to a dog, at an amount of between about 5g/dog/day and about 95g/dog/day, or preferably between about 20g/dog/day and about 80g/dog/day, or preferably between about 20g/dog/day and about 70g/dog/day, or preferably between about 20g/dog/day and about 60g/dog/day, or preferably between about 20g/dog/day and about 50g/dog/day, or preferably between about 20g/dog/day and about 40g/dog/day, or preferably between about 30g/dog/day and about 80g/dog/day, or preferably between about 30g/dog/day and about 70g/dog/day, or preferably between about 30g/dog/day and about 60g/dog/day, or preferably between about 30g/dog/day and about 50g/dog/day, or preferably between about 30g/dog/day and about 40g/dog/day, or preferably between about 40g/dog/day and about 80g/dog/day, or preferably between about 40g/dog/day and about 70g/dog/day, or preferably between about 50g/dog/day and about 70g/dog/day. These amounts are based on a dog weight of about 60lb. The amounts can be adjusted accordingly based on the weight of the individual animal.

[0180] In one aspect, the present description includes a method of providing a fiber energy composition to a cat at an amount of between about 4g/cat/day and about 40g/cat/day, or preferably between about 8g/cat/day and about 35g/cat/day, or preferably between about 8g/cat/day and about 30g/cat/day, or preferably between about 8g/cat/day and about 25g/cat/day, or preferably between about 8g/cat/day and about 20g/cat/day, or preferably between about 8g/cat/day and about 15g/cat/day, or preferably between about 10g/cat/day and about 35g/cat/day, or preferably between about 10g/cat/day and about 30g/cat/day, or preferably between about 10g/cat/day and about 25g/cat/day, or preferably between about 10g/cat/day and about 20g/cat/day, or preferably between about 10g/cat/day and about 15g/cat/day, or preferably between about 15g/cat/day and about 35g/cat/day, or preferably between about 15g/cat/day and about 30g/cat/day, or preferably between about 15g/cat/day and about 25g/cat/day, or preferably between about 15g/cat/day and about 20g/cat/day. These amounts are based on a average cat weight of about 12lb. The amounts can be adjusted accordingly based on the weight of the individual animal.

[0181] The method further includes feeding pets one or more times per day, preferably two or more times per day, or preferably three or more times per day. The method includes providing the fiber energy composition with at least one feeding, or preferably with at least two feedings, or preferably with every feeding.

[0182] The dried extruded product can be milled. The milling and sieving step (d) is used to reduce the size of product particles, aiming at better homogeneity, and to improve the quality of the final product. The particle size after the step (d) can be standardized in 0.25 - 5 mm, preferably 3 mm. After the milling step, the final product is mixed and remains stored awaiting sieving, and packing.

[0183] Representative features of the present invention are set out in the following clauses, which stand alone or may be combined, in any combination, with one or more features disclosed in the text of the specification.

[0184] The present invention is as set out in the following clauses:

[0185] Clause 1. A fiber energy composition comprising a fiber/gum extrudate, wherein the fiber/gum extrudate comprises one or more fibers and a gum, wherein the gum is an oilseed gum comprising hydratable phospholipids, lyso-phospholipids or a combination thereof.

[0186] Clause 2. The fiber energy composition of clause 1, wherein the fiber comprises soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations thereof.

[0187] Clause 3. The fiber energy composition of clauses 1 or 2, wherein the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

[0188] Clause 4. The fiber energy composition of any one of the preceding clauses, wherein the fiber comprises soybean hulls and the gum comprises soybean gum, wherein the soybean gum comprises phospholipids, lyso-phospholipids, oil, water or any combinations thereof, preferably the fiber energy composition does not include a starch source.

[0189] Clause 5. The fiber energy composition of any one of the preceding clauses, comprising about 30wt%-90wt% of soybean hulls, preferably about 40-80wt% of soybean hulls, preferably

50-80wt%, preferably 50-70wt% wt of soybean hulls, based on the total weight of the dry base composition.

[0190] Clause 6. The fiber energy composition of any one of the preceding clauses, comprising about 5-50wt% of gum based on the total weight of the dry base composition.

[0191] Clause 7. The fiber energy composition of any one of the preceding clauses, further comprising one or more additional ingredients selected from the group comprising antioxidants, grains, minerals, enzymes, wherein the amount of one or more additional ingredients is between about 1-25wt% based on the total weight of the dry base composition.

[0192] Clause 8. The fiber energy composition of any one of the preceding clauses, wherein the gum comprises phosphatidylcholine (PC) phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl choline (PC), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI). lyso-phosphatidylcholine (LPC) or any combinations thereof.

[0193] Clause 9. The fiber energy composition of any one of the preceding clauses, wherein the fiber energy composition comprises soy/soy composition, soy/rapeseed composition, rapeseed/rapeseed composition and/or combinations thereof.

[0194] Clause 10. Use of an extrusion process, to produce a fiber energy composition of any one of clauses 1-9.

[0195] Clause 11. A method to produce a fiber energy composition, the method comprising extruding one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and lyso-phospholipids.

[0196] Clause 12. The method of clause 11, wherein the fiber is soybean hulls and the gum is soybean gum, wherein the fiber and the gum are blended without the addition of water prior to the extruding.

[0197] Clause 13. The method of any one of clauses 11-12, wherein the extruding comprises the steps of (a) blending the fiber, the gum to generate a blended mixture; (b) extruding the blended mixture to generate a fiber/gum extrudate.

[0198] Clause 14. The method of any one of clauses 11-13, wherein the method further comprises (c) drying and cooling the fiber/gum extrudate; (d) optionally, milling and sieving the fiber/gum extrudate to form the fiber energy composition; and (e) storing the fiber energy composition.

[0199] Clause 15. The method of any one of clauses 11-14, wherein the blending step (a) is a continuous or a batch process.

[0200] Clause 16. The method of any one of clauses 11-15, wherein the blending step (a) is conducted for at least 1 minute, preferably between 5 minutes and 60 minutes.

[0201] Clause 17. The method of any one of clauses 11-16, wherein the method further comprises additional ingredients and wherein the fiber, the gum and the additional ingredients are blended prior to the extruding.

[0202] Clause 18. The method of any one of clauses 11-17, wherein the extruding step (b) comprises extruding with a single screw extruder or a twin-screw extruder.

[0203] Clause 19. The method of any one of clauses 11-18, wherein the temperature varies between 25°C to 200°C, and the pressure varies between 5-50Bar in the extruding step (b).

[0204] Clause 20. The method of any one of clauses 11-19, wherein in the drying step (c) the temperature varies from about 90°C to 200°C.

[0205] Clause 21. A fiber energy composition obtained by any of the methods of clauses 11-20.

[0206] Clause 22. Use of an extrusion process, to produce a fiber energy composition comprising one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

[0207] Clause 23. The use of an extrusion process as in clause 22, wherein the fibers comprise soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

[0208] Clause 24. An enriched animal feed comprising a fiber energy composition, wherein the fiber energy composition comprises a fiber/gum composition comprising one or more fibers and a gum, wherein the fiber energy composition is an extrudate, wherein the gum comprises hydratable phospholipids and lyso-phospholipids.

[0209] Clause 25. The enriched animal feed of clause 24, wherein the fiber comprises soybean hulls, rice hulls and/or combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum and/or combinations thereof, preferably the one or more fibers comprise soybean hulls and the gum comprises soybean gum.

[0210] Clause 26. The enriched animal feed of any one of the preceding clauses 24-25, comprising 30wt%-90wt% of soybean hulls based on the total weight of the dry base composition.

[0211] Clause 27. The enriched animal feed of any one of the preceding clauses 24-26, comprising about 5-50wt% of gum based on the total weight of the dry base composition.

[0212] Clause 28. The enriched animal feed of any one of the preceding clauses 24-27, further comprising one or more additional ingredients selected from the group comprising antioxidants, grains, minerals, enzymes, wherein the amount of one or more additional ingredients is between about 1-25wt% based on the total weight of the dry base composition.

[0213] Clause 29. The enriched animal feed of any one of the preceding clauses 24-28, wherein the gum comprises phosphatidylcholine (PC) phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl choline (PC), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI), lyso-phosphatidylcholine (LPC) or any combinations thereof.

[0214] Clause 30. The enriched animal feed of any one of the preceding clauses 24-29, wherein the animal feed comprises the fiber/gum composition at an inclusion rate of between 1wt% and about 20wt%.

[0215] Clause 31. The enriched animal feed of any one of the preceding clauses 24-30, wherein the animal feed is an additive, a premix, a ration or combination thereof.

[0216] Clause 32. The enriched animal feed of any one of the preceding clauses 24-31, wherein the animal feed is a swine feed, an equine feed, a pet food, a ruminant feed or combinations thereof.

[0217] Clause 33. The enriched animal feed of any one of the preceding clauses 24-32, wherein the animal feed is a swine feed and the inclusion rate is between about 2.5wt% and about 10wt%.

[0218] Clause 34. A method for feeding an animal, comprising providing a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

[0219] Clause 35. The method for feeding an animal according to clause 34, wherein the one or more fibers comprise soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn

meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

[0220] Clause 36. The method for feeding an animal according to clause 35, wherein the animals comprise ruminants, swine, equine, dogs, cats or any combinations thereof.

[0221] Clause 37. The method for feeding an animal according to any one of the clauses 34-36, wherein the fiber/gum composition comprises soybean hulls and soybean gum.

[0222] Clause 38. The method for feeding an animal according to any one of the clauses 34-37, wherein the animal is provided an animal feed comprising the fiber energy composition at an inclusion rate of between about 2wt% up 15 wt%, preferably between 3wt to 10wt%%, more preferably between 5 – 8wt%.

[0223] Clause 39. A method for feeding swine comprising providing a fiber/gum composition to the swine, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

[0224] Clause 40. The method for feeding swine according to clause 39, wherein the fiber comprises soybean hulls, rice hulls or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

[0225] Clause 41. The method for feeding swine according to any one of the clauses 39-40, wherein the swine are piglets and/or lactating sows.

[0226] Clause 42. The method for feeding swine according to any one of the clauses 39-41, wherein the animal is provided an enriched animal feed comprising the fiber energy composition at an inclusion rate of between about 2wt% up 15 wt%, preferably between 3wt to 10wt%%, more preferably between 5 – 10wt%, or preferably 7.5wt%.

[0227] Clause 43. The method for feeding swine according to any one of the clauses 39-42, wherein the fiber energy composition is provided to the lactating sows from farrowing until weaning or any range there between.

[0228] Clause 44. The method for feeding swine according to any one of the clauses 39-43, wherein the fiber energy composition is provided to the piglets from about day 28 of life to about day 65 of life.

[0229] Clause 45. The method for feeding swine according to any one of the clauses 39-44, wherein the fiber energy composition is provided at least once a day.

[0230] Clause 46: The method for feeding swine according to any one of the clauses 39-45, wherein the amount of the fiber energy composition provided to the piglet is between about 20g/piglet/day and 70g/piglet/day and/or wherein the amount of fiber energy composition provided to the sow is between about 200g/sow/day and 700g/sow/day.

[0231] Clause 47. A method for feeding an equine, comprising providing a fiber energy composition to an equine animal, wherein the fiber energy composition comprises a fiber/gum composition to the equine animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

[0232] Clause 48: The method for feeding an equine according to clause 47, wherein the fiber energy composition is provided in the equine feed at an inclusion rate of between about 4wt% to 12wt% and/or wherein the amount of the fiber energy composition provided to the equine is between about 1000g/horse/day and about 2000g/horse/day.

[0233] Clause 49. A method for feeding a ruminant, comprising providing a fiber energy composition to a ruminant, wherein the fiber energy composition comprises a fiber/gum composition to the ruminant, wherein the fiber energy composition comprises a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

[0234] Clause 50: The method for feeding a ruminant according to clause 49, wherein the fiber energy composition is provided in the ruminant feed at an inclusion rate of between about 4wt% to 12wt%.

[0235] Clause 51: A method for feeding a pet, comprising providing a fiber energy composition to a pet, preferably the pet is a dog and/or a cat, wherein the fiber energy composition comprises a fiber/gum composition to the pet, wherein the fiber energy composition comprises a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more

fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

[0236] Clause 52: The method for feeding a pet according to claim 51, wherein the fiber energy composition is provided in the equine feed at an inclusion rate of between about 5wt% to 10wt% and/or wherein the amount of the fiber energy composition provided to the dog is about 20g/dog/day and about 70g/dog/day based on a 60lb dog and/or wherein the amount of the fiber energy composition provided to the cat between about 10g/cat/day and about 25g/cat/day.

EXAMPLES

[0237] The invention is further described in detail by reference to the following experimental examples. These examples are provided for purposes of illustration only and are not intended to be limiting unless otherwise specified. Thus, the invention should in no way be construed as being limited to the following examples, but rather should be construed to encompass any and all variations which become evident as a result of the teaching provided herein.

EXAMPLE 1 – Extrusion of fiber/gum composition

[0238] The description of the parameters for conducting an extrusion process is for illustrative purposes and other extrusion processes may be used.

[0239] Extrusion was conducted at the Grain Science and Industry Bioprocessing and Industrial Value-Added Products Innovation Center at Kansas State University (Manhattan, KS), using the following parameters: A twin-screw extruder (Wenger TX-52; Wenger Manufacturing Inc., Sabetha, KS) was used. The screw speed was 350 rpm. The maximum barrel temperature was 80°C, and in-barrel moisture was 40%. The extruded product passed through a die that had a diameter of 2.5 mm. The temperature in the preconditioner was 85°C. The temperature and pressure in the cannon had a mass temperature 130°C and pressure 20 Bar. The temperature in the dryer was an average of 110°C. The agitation (mixing) time in the homogenizer used was 10 minutes/batch. The die had a single hole of 6 mm. There was no addition of steam in the cannon.

[0240] A person skilled in the art knows that might be acceptable differences between the described parameters in this example and a line used in pilot production. In addition, a person

skilled in the art will certainly know that there are differences in the industrial line when implemented industrially.

EXAMPLE 2-Extrusion of soybean hulls and soybean gum

[0241] Four (4) samples of formulations comprising soybean hulls and gum were processed using the similar conditions as defined in Example 1:

(I) 60% hulls + 10% gum + 30% corn.

[0242] The gum was easily incorporated into the ground hulls (10 minutes of agitation). 200 ppm of antioxidant BHT was added. After stabilization, the product extruded easily forming stable pellets. The product then dried easily under the established conditions (about 100°C).

(II) 50% hulls + 30% gum + 20% corn.

[0243] The gum was easily incorporated into the ground hulls (15 minutes of agitation). 200 ppm of antioxidant BHT was added. After stabilization, the product extruded well but with stable pellet. The product then dried easily under the established conditions (about 100°C).

(III) 90% hulls + 10% gum.

[0244] The gum was easily incorporated into the ground hulls (10 minutes of agitation). 200 ppm of antioxidant BHT was added. After stabilization, the product extruded well but formed fragile pellets. The product did not dry easily under the established conditions (about 100°C).

(IV) 70% hulls + 30% gum.

[0245] The gum was easily incorporated into the ground hulls (15 minutes of agitation). 200 ppm of antioxidant BHT was added. After stabilization, the product did not extrude easily and did not form a pellet. The product did not dry easily under the established conditions (about 100°C).

[0246] 300kg of compositions I and II were produced with subsequent extrusion and drying. Approximately 150kg of each fraction.

[0247] 150kg of compositions III and IV were produced with subsequent extrusion, but without drying (dryer limitation).

[0248] Samples were collected from the 4 (four) fractions for laboratory tests. Fractions III and IV were dried in a laboratory oven.

[0249] In general terms, the gum is easily incorporated into the ground hull, indicating that the fibers play an adsorbent role. The homogenization of the gum in the hull occurs more easily without the presence of corn. The corn starch is an extrusion aid, providing good pellet formation, which facilitates drying.

[0250] According to the observations made, it would be possible to add higher levels of gum, as long as the drying process is appropriate for the meal product, as well as a longer residence time. Elevating gum levels makes it more difficult to remove water, but it is possible to do it industrially in an atmospheric dryer. And addition of antioxidant (together with gum) could prevent oxidation of the product.

[0251] All raw materials were transported and kept under refrigeration, to avoid deterioration of the gum and microbiological growth.

EXAMPLE 3-Use of soybean hulls and soybean gum extrudate in feeding piglets

[0252] An experimental formulation was included in pig nutrition to evaluate weight yield, overall cost and productivity improvement.

[0253] The productive phases of pigs are divided into 4 stages: breastfeeding (0-28 days), nursery (28-63 days), growth (63-105 days) and finishing (105-140 days). Each cycle follows a calendar of days, where the diet is formulated according to nutritional requirements.

[0254] The experiment with the gum enriched soybean hulls of the invention was structured for the nursery phase, where the animal receives a formulated feed between 28-63 days, at the end of which, the formulation is adjusted for the next stage.

[0255] The experiment with young animals was carried out at the experimental farm of Cargill AN&H located in Mogi Mirim/SP, where a lot with 240 piglets were divided into 48 pens containing 5 animals each.

[0256] Four diet formulations were prepared: a control and inclusions of 2.5wt%, 5.0wt% and 7.5wt% of the soy/soy fiber energy composition. The animals were segregated into pens to monitor weight gain over four weeks. Regarding the formulations, composition adjustments were made by reducing the amount of oil and adding the soy/soy fiber energy composition, resulting in a new energy balance of each formula.

[0257] In the stomach, the secretion of hydrochloric acid by the stomach mucosa derives from nervous and hormonal stimuli and the presence of food, which increases stomach pH. The result will be a gradual reduction in the pH and the denaturation of the dietary proteins with the opening of the molecules and elimination of the tertiary structure, which will facilitate the access of the proteolytic enzymes in the stomach and small intestine. When digest reaches the duodenum, it mixes with alkaline secretions from the liver (bile) and pancreas (pancreatic juice) which raise the intestinal pH to facilitate the action of pancreatic enzymes. The digestion of carbohydrates and

proteins in the small intestine is very fast and intense due to the action of pancreatic enzymes responsible for digestion in the intestinal lumen and the enzymes present in the intestinal mucosa.

[0258] For the weight gain parameter, at the end of the transition phase, a linear and increasing performance curve was observed in the diets containing the additive composed of the soy/soy fiber energy composition. The total weight gain in the transition phase and the daily weight gain (GPD) showed a linear statistical correlation of performance, demonstrating the positive effect of the soy/soy fiber energy composition on the performance of the animals. See Figures 3, 4 and 5.

TRIAL

[0259] Soy/soy fiber energy composition (I): 60% soy hulls, 30% corn and 10% dry gum were extruded as described in Example 1 and 2.

Table 2

	T1	T2	T3	T4
Basal diet	92.5wt%	92.5wt%	92.5wt%	92.5wt%
Soyhull:soy oil:corn (non-extruded composition with soy oil)	7.5wt%	5.0wt%	2.5wt%	0wt%
Extruded fiber energy composition (Soyhull:soy gum:corn (60:30:10))	0wt%	2.5wt%	5wt%	7.5wt%
Percentage of soy oil replaced with extruded fiber energy composition	0wt%	33wt%	66wt%	100wt%

CONCLUSIONS

[0260] Results from the treatments in the overall trial period (day 21 to 63 of age) are shown below in Table 3.

Table 3

	% of replacement					P-value	SEM
	0%	33%	66%	100%			
Initial Weight, kg	5.63	5.65	5.66	5.65		0.4912	0.1138
Final Weight, kg	24.78	25.34	25.78	25.93	B,AB,AB,A	0.0729	0.3227
Weight Gain, kg	19.15	19.70	20.13	20.29	B,AB,AB,A	0.0761	0.2355
Daily Gain, g/d	456.00	469.00	479.00	483.00	B,AB,AB,A	0.0787	5.61
Feed Intake, kg	26.20	27.00	27.50	27.30		0.4693	0.3343

Daily Feed Intake, g/day	621.00	643.00	654.00	651.00		0.42	0.7800
Feed conversion ratio (kg/kg)	1.36	1.37	1.36	1.35		0.67	0.0067

[0261] Inclusion of Fiber Energy increased gain linearly in the transition phase (21 to 42 days). From T4 vs T1, led to 498 g more gain per animal or almost 8% increase. Consequently, animals were 518 grams, or 4%, heavier at the end of the transition phase. With a similar feed intake, feed conversion ratio was significantly lower in T4 versus T1 (P=0.02).

[0262] Inclusion of Fiber Energy increased gain quadratically in the Starter phase (42 to 63 days). Reaching a plateau with 5% inclusion (T3). From T3 vs T1, led to 660 g more gain per animal or almost 5% increase. Other than growth, no effects were found.

[0263] Overall period (21 to 63 days), T4 vs T1 increased gain in 1,140 g or 6% more (quadratic effect). Consequently, T4 animals tended to be heavier (1.14 kg) compared to T1 animals.

EXAMPLE 4-Use of soybean hulls and soybean gum extrudate in feeding lactating sows

A total of 147 individually housed lactating sows within parity range 1 to 7 (mean parity 3.4) were used. Majority of the sows were DanBred, followed by Camborough and TN70 genetics. Sows were randomly assigned to one of three treatments (T1 to T3). Sows were provided the treatments when they entered the farrowing room, on average 3 days before farrowing, until the end of lactation (21-23 days). T1 consisted of a corn soybean meal base diet with soy oil (control). In T2, oil inclusion was reduced by 50% and consequently the energy content of this treatment was reduced (negative control/NC). T3 was similar as T2 but with inclusion of 5% Fiber Energy (NC + Fiber Energy). Table 4 (below) shows the oil inclusion and net energy content (SW CNE LAC) of the 3 treatments. The energy levels of #2 and #3 are similar but below the energy level in #1 due to the lower oil inclusion.

Table 4

Treatments	Soy oil, wt%	SW CNE LAC ^a (kcal/kg)
T1-Control	4	2851
T2-Negative control (NC)	2	2751
T3-NC + Fiber energy 5wt%	2	2743

^aSW-swine; CNE-Cargill net energy; LAC-lactating sows

[0264] Results:

[0265] Table 5 shows the results from a number of parameters measured.

Table 5

Variables	Unit	Treatments			P-values		Treatment x Parity	Tukey separation for treatments effect
		Control	Control lower energy	Fiber Energy (5%)	Treatment	Parity		
BW at entry	kg	254	254	257	0.7880	<0,0001	0.4730	
Sow BW at weaning	kg	211	209	212	0.7830	<0,0001	0.3250	
Total born	#	18.8	17.9	19.5	0.0625	0.1010	0.4031	ab,b,a
Born Alive	#	16.5	16.5	16.9	0.7490	0.5160	0.5020	
Mummies	%	1.68	2.23	1.9	0.6815	0.7671	0.0828	
Stillborn	%	1.86	1.54	2.04	0.2460	0.2370	0.4360	
Lighter than 500 g	%	1.55	1.11	1.5	0.8380	0.3690	0.7850	
Pre weaning mortality	%	8.8	8.11	6.07	0.2540	0.4900	0.3350	
Weaned	#	12.1	12.3	12.6	0.7090	0.1810	0.2970	
Weaning weight	kg	5.2	4.75	5.05	0.0235	<0,0001	0.9747	a,b,ab
BW gain/pig	kg	3.87	3.34	3.7	0.0044	<0,0001	0.9891	a,b,ab

ADG	kg	0.181	0.156	0.175	0.0039	<0,0001	0.9793	a,b,ab
Litter gain	kg	41.5	36.8	42.1	0.2290	0.3460	0.8800	
Litter ADG	kg	2.2	1.92	2.2	0.0391	0.0460	0.9819	a,b,a
Birth weight	kg	1.22	1.31	1.21	0.0397	0.0070	0.9204	ab,a,b
FI pre-farrow	kg	2.28	2.31	2.28	0.9400	0.2320	0.8670	
FI 0-7d pos farrow	kg	3.84	4.23	4.04	0.3900	<0,0001	0.7410	
FI 8-15d pos farrow	kg	7.31	7.44	7.41	0.8301	0.0073	0.8235	
FI 16-weaning	kg	9.49	9.58	9.16	0.1073	0.0801	0.7750	
Total Feed Intake	kg	168	173	168	0.2453	0.0020	0.7432	
Livability	%	80	79.4	83.5	0.4170	0.6050	0.3620	

Table 6

Treatments	Weaning weight (kg)	Number of pigs at weaning	Litter weight (kg)
#1-Control	5.2(a)	12.1	62.9
#2-Negative control (NC) (Low energy)	4.75(b)	12.3	58.4
#3-NC + Fiber energy 5wt%	5.05(ab) <i>P=0.02</i>	12.6	63.6

[0266] From the results it can be observed that piglets from sows fed T2 gained significantly less weight (-13%, $P < 0.01$) compared to piglets from sows fed T1. Consequently, weaning weights were reduced by almost 9% ($P = 0.02$). On the other hand, piglets from sows receiving T3 had similar gain and weaning weights compared to T1. In addition, sow body weight at weaning was similar across T1 and T3. These results suggest that reducing the energy content of the sow feed (by approximately 100 kcal) negatively affects piglet performance. However, adding Fiber Energy to a diet reduced in energy content ameliorates this negative effect. It can be hypothesized that Fiber Energy is making up for the lower energy thru its emulsification properties and increased digestibility.

[0267] **PROPHETIC EXAMPLES**

[0268] **Prophetic Example 1-Effect of Fiber energy composition dietary inclusion in mature horses**

Objective: To investigate the influence of Fiber energy composition ingredient use on body weight, body condition score, glycemic/ insulinemic response, and apparent nutrient digestibility in mature horses fed a commercial soy-based ration.

[0269] **MATERIALS AND METHODS**

[0270] **Dietary treatments**

[0271] The influence of dietary inclusion of fiber energy composition on mature horse body weight, body condition score, glycemic/ insulinemic response, and apparent nutrient digestibility will be examined using the following protocol. Eighteen mature Quarter horse geldings will be used in a complete randomized block design. Prior to the start of the study horses will be stratified by age and BW and randomly assigned to one of three treatments: Control, a traditional pelleted equine diet (CON; $n = 6$), a multiform diet consisting of a pellet and extruded fiber energy composition nugget (FIBM; $n = 6$), and a fully extruded diet containing fiber energy composition components as well as the other dietary components (protein, starch, vitamin/mineral) within the same extruded nugget (FIBC, $n=6$). Dietary treatments will be formulated to be isocaloric and isonitrogenous, contain the same ingredients (soy hulls, soybean meal, oats (starch), soy oil or gum (depending on form), and a vitamin and mineral premix) and be fed at 0.5% BW (as-fed) daily. All horses will receive 1.5% BW coastal Bermudagrass (*Cynodon dactylon*) hay (as-fed) daily (Table 7).

[0272] Horses will be individually stall fed the daily ration divided into two feedings daily and allowed 3 h to consume their meal. Orts (refusals) will be collected and weighed. Horses will always have free choice access to water, but will otherwise be group housed in dry-lot conditions to avoid variable pasture consumption.

[0273] Table 7. Nutrient composition of treatment diets used in the experiment (% DM basis).

	CON	FIBM	FIBC
Crude Protein	13	13	13
Crude Fat	10	10	10
Crude Fiber	13	13	13
NSC (sugar + starch	20	20	20
% fiber energy composition	0	30	30

[0274] Experimental Protocol

[0275] The experiment will be divided into 4 phases: 1) 7d transition to dietary treatments, 2) 14d adaptation to dietary treatments, 3) 4d total fecal collection, and 4) 1d glycemic response study for a total duration of 28d.

[0276] For the total fecal collection (d 22-25) fecal collection bags (Equine Nappies) will be placed on geldings to collect feces over a 24-h period. Bags are removed and emptied at 0630, 1230, 1830, and 0030 h daily. The feces collected over each 6 h sampling period is homogenized, and a sample taken (3% of total fecal matter) and frozen at -20°C.

[0277] For the glycemic index on d 28 horses will be placed into feeding stalls and catheterized one hour before the start of the glycemic response test. A jugular catheter site is prepared by clipping the coat to a sanitary length (blade size 40) and sterilized using Chloradine scrub 4% in addition to isopropyl alcohol 70%. Lidocaine is used as a local anaesthetic and injected subcutaneously at the site of catheter insertion. Catheters are placed and a 30-inch extension set attached to the catheter and secured with Elasticon. All horses are allowed to acclimate for a minimum of 1-h after catheters were placed and prior to sampling. Glucose samples are taken at 0, 30, 60, 90, 120, 150, 180, 210, 240, 300, 360, 420, and 480 minutes after feeding and insulin samples at 0, 60, 120, 180, 240, 360, 480 minutes after feeding. Time to complete the concentrate will be recorded and considered as a cofactor in analyses.

[0278] Sample Analysis

[0279] Concentrate, hay, ort, and fecal samples will be dried at 55°C in a forced-air oven for 96-h, allowed to equilibrate for 24-h, and weighed for determination of partial DM. Samples will be ground in a Wiley mill to pass a 1 mm screen. Hay and feed samples collected during the period are pooled across days on an equal weight basis. Ort samples are composited in proportion to their daily refusal by horse across days, while fecal samples are composited by gelding across days. Hay, concentrate, fecal, and ort samples are dried at 105°C for 24-h to determine DM. Organic Matter (OM) is determined by the loss in dry weight during combustion for 8 h at 450°C. Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Crude Protein (CP), Fat (FAT) analysis will be performed on feed, hay, ort, and fecal samples traditional laboratory techniques. Direct calorimetry using a Parr 6300 Calorimeter (Parr Instrument Company, Moline, IL) will be utilized to measure gross heat of hay, feed, ort, and fecal samples. Apparent digestibility of energy will be calculated as the remainder of consumed minus fecal excreted energy expressed as a percentage of intake. Total tract apparent digestion coefficients for DM, OM, NDF, ADF, CP, and FAT will be determined using total collection, as described by Cochran and Galyean (1994).

[0280] For the glycemic response, a commercial glucose colorimetric assay kit (Cell Biolabs, Inc., San Diego, CA) will be utilized to evaluate the plasma glucose concentrations in the blood. Samples will be analyzed in duplicate. Plasma insulin concentrations will be determined by an equine ELISA kit (Mercodia Inc., Winston Salem, NC), a two-site enzyme immunoassay.

[0281] Statistical Analysis

[0282] Intake, digestion, and rate of intake will be analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Term in the model was treatment and LSMEANS was used to calculate treatment means. Area under the curve (AUC) for glucose and insulin concentrations will be determined using PROC EXPAND procedure of SAS (SAS Inst. Inc., Cary, NC). All AUC data and peak concentrations of glucose and insulin will be analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Main effects tested are treatment, time, and treatment by time interaction. A paired t-test will be used to compare differences between dietary treatments. Means are reported as LSMeans $\pm$ SD. Statistical significance is defined as $P \leq 0.05$ and trends toward significance are declared when $P \leq 0.10$.

[0283] **Expected Results**

[0284] Body weight and body condition score will be unchanged due to treatment or time due to the short duration of the study (28d).

[0285] Greater apparent digestibility for DM, OM, NDF, ADF, CP, and Fat will be observed in the FIBM and FIBC diets compared to control, with no difference between FIBM and FIBC.

[0286] Glycemic/Insulinemic response will be greater in FIBC and FIBM than control due to increased starch digestibility. FIBC will show greater less glycemic response than FIBM due to increased feed consumption time.

[0287] **Prophetic Example 2-Effect of Fiber Energy dietary inclusion in ruminants**

[0288] **OBJECTIVE:** To investigate the influence of Fiber Energy supplementation on reproductive and growth performance and nutrient digestibility in ruminants fed complete and balanced extruded feed with fiber energy composition.

[0289] **MATERIALS AND METHODS:**

[0290] **Dietary treatments:** The influence of fiber energy supplementation on reproductive and growth performance and nutrient digestibility in ruminants will be examined in these experiments.

[0291] Diets will be used as listed in Table 8 and 9. All diets will be extruded per current formulation processing specifications for each finished product.

Table 8

Transition cows: use of gums and digestible fiber	
Performance Trials	
PC	Rumen protected choline (60 g/d)
NC	No RP-Choline
Fiber Energy	NC+2.0 kg FE
Calves: use of fiber energy composition to stimulate rumen development will be monitored	

Table 9

Control	Standard calf stater using soyhulls and corn
FE low	partial replacement (15%) of SH and Corn by Fiber energy
FE mid	partial replacement (30%) of SH and Corn by Fiber energy
FE high	partial replacement (45%) of SH and Corn

	by Fiber energy
--	-----------------

[0292] Parameters Measured

[0293] Digestibility: Nutrient digestibility coefficients for select dietary treatments will be determined.

[0294] EXPECTED RESULTS

[0295] Reproductive and Growth Performance and Nutrient Digestibility

[0296] I. Performance between PC, NC and Fiber Energy will be determined.

[0297] II. Fiber Energy will regain some of the decrease in performance through improving fat/oil digestibility.

[0298] III. Digestibility results in general will be higher for diets with Fiber Energy as emulsification of fat leads to better digestion of fats and oils together with increased uptake of other nutrients especially fat-soluble ones.

[0299] IV. Due to the components and benefits of Fiber Energy, the current commercial formulations should be able to decrease fat and choline inclusion in the formulations and realize cost savings.

[0300] **Prophetic Example 3-Effect of Fiber Energy dietary inclusion in pet food**

[0301] OBJECTIVE: To investigate the influence of fiber energy supplementation on reproductive and growth performance and nutrient digestibility in dogs and cats fed complete and balanced extruded dry pet foods.

[0302] MATERIALS AND METHODS:

[0303] Dietary treatments: The influence of Fiber Energy supplementation on reproductive and growth performance and nutrient digestibility in dogs and cats will be examined in these experiments. Six dietary treatments per species will be used (Table 10).

[0304] Diets 1 to 7 (Reproductive/Growth performance, and Digestibility trial): For each specie's dietary treatments, a Positive Control (PC) diet based on a current Cargill complete and balanced dry extruded commercial pet food will be produced (Black Gold Explorer and Loyall Life). A negative control diet (NC) (PC with -10% kcals/kg) will also be formulated by decreasing fat. The PC and NC diets will then be used to develop 5 additional dietary treatments with graded levels of Fiber Energy % (2.5, 5.0, 7.5, and 10.0).

[0305] All diets will contain an inert marker for determination of nutrient digestibility coefficients. All diets will be extruded per current formulation processing specifications for each finished product.

Table 10

Treatment	Diet type	fiber energy composition Inclusion %
1	PC	0
2	NC (PC – 10% Energy from fat)	0
3	NC + Fiber Energy 2.5	2.5
4	NC + fiber energy composition 5.0	5.0
5	NC + fiber energy composition 7.5	7.5
6	NC + fiber energy composition 10.0	10.0
7	PC + fiber energy composition 7.5	7.5

[0306] Parameters Measured

[0307] Reproductive and Growth Performance: All Life Stage AAFCO protocols will be conducted for select dietary treatments according to the AAFCO Official Publication 2024 for each species.

[0308] Digestibility: Nutrient digestibility coefficients for select dietary treatments will be determined via AAFCO protocols as outlined in the AAFCO Official Publication 2024 for each species.

[0309] EXPECTED RESULTS

[0310] Reproductive and Growth Performance and Nutrient Digestibility

[0311] I. Performance between PC and NC. Performance of pets of PC will be better compared to NC due to the lower feed energy level.

[0312] II. Performance between PC, NC, and NC plus Fiber Energy. (NC + Fiber Energy) Fiber Energy will regain some of the decrease in performance through improving fat/oil digestibility.

[0313] III. Performance between PC plus Fiber Energy and NC Plus Fiber Energy. PC plus Fiber Energy will perform better than NC plus Fiber Energy. Fiber Energy will maximize total fat digestion in the food giving an uplift in performance. Better emulsification from the Fiber Energy has the benefits of increased uptake of fat-soluble nutrients which contributes to better performance.

[0314] IV. Digestibility results in general will be higher for diets with Fiber Energy as emulsification of fat leads to better digestion of fats and oils together with increased uptake of other nutrients especially fat-soluble ones.

[0315] V. Due to the components and benefits of Fiber Energy, the current commercial formulations should be able to decrease fat and choline inclusion in the formulations and realize cost savings.

[0316] In this document, the terms “a,” “an,” or “the” are used to include one or more than one unless the context clearly dictates otherwise. The term “or” is used to refer to a nonexclusive “or” unless otherwise indicated. All publications, patents, and patent documents referred to in this document are incorporated by reference herein in their entirety, as though individually incorporated by reference. In the event of inconsistent usages between this document and those documents so incorporated by reference, the usage in the incorporated reference should be considered supplementary to that of this document; for irreconcilable inconsistencies, the usage in this document controls.

[0317] Values expressed in a range format should be interpreted in a flexible manner to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range were explicitly recited. For example, a range of “about 0.1% to about 5%” or “about 0.1% to 5%” should be interpreted to include not just about 0.1% to about 5%, but also the individual values (e.g., 1%, 2%, 3%, and 4%) and the sub-ranges (e.g., 0.1% to 0.5%, 1.1% to 2.2%, 3.3% to 4.4%) within the indicated range. The statement “about X to Y” has the same meaning as “about X to about Y,” unless indicated otherwise. Likewise, the statement “about X, Y, or about Z” has the same meaning as “about X, about Y, or about Z,” unless indicated otherwise.

[0318] Unless expressly stated, ppm (parts per million), percentage, and ratios are on a by weight basis. Percentage on a by weight basis is also referred to as wt% or % (wt) below.

CLAIMS

What is claimed is:

1. A fiber energy composition comprising a fiber/gum extrudate, wherein the fiber/gum extrudate comprises one or more fibers and a gum, wherein the gum is an oilseed gum comprising hydratable phospholipids, lyso-phospholipids or a combination thereof.

2. The fiber energy composition of claim 1, wherein the fiber comprises soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations thereof.

3. The fiber energy composition of claims 1 or 2, wherein the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

4. The fiber energy composition of any one of the preceding claims, wherein the fiber comprises soybean hulls and the gum comprises soybean gum, wherein the soybean gum comprises phospholipids, lyso-phospholipids, oil, water or any combinations thereof.

5. The fiber energy composition of any one of the preceding claims, comprising about 30wt%-90wt% of soybean hulls, preferably about 40-80wt% of soybean hulls, preferably 50-80wt%, based on the total weight of the dry base composition.

6. The fiber energy composition of any one of the preceding claims, comprising about 5-50wt% of gum based on the total weight of the dry base composition.

7. The fiber energy composition of any one of the preceding claims, further comprising one or more additional ingredients selected from the group comprising antioxidants, grains, minerals, enzymes, wherein the amount of one or more additional ingredients is between about 1-25wt% based on the total weight of the dry base composition.

8. The fiber energy composition of any one of the preceding claims, wherein the gum comprises phosphatidylcholine (PC) phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl choline (PC), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI), lyso-phosphatidylcholine (LPC) or any combinations thereof.

9. The fiber energy composition of any one of the preceding claims, wherein the fiber energy composition comprises soy/soy composition, soy/rapeseed composition, rapeseed/rapeseed composition and/or combinations thereof.

10. Use of an extrusion process, to produce a fiber energy composition of any one of claims 1-9.

11. A method to produce a fiber energy composition, the method comprising extruding one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and lyso-phospholipids.

12. The method of claim 11, wherein the fiber is soybean hulls and the gum is soybean gum, wherein the fiber and the gum are blended without the addition of water prior to the extruding.

13. The method of any one of claims 11-12, wherein the extruding comprises the steps of (a) blending the fiber, the gum to generate a blended mixture; (b) extruding the blended mixture to generate a fiber/gum extrudate.

14. The method of any one of claims 11-13, wherein the method further comprises (c) drying and cooling the fiber/gum extrudate; (d) optionally, milling and sieving the fiber/gum extrudate to form the fiber energy composition; and (e) storing the fiber energy composition.

15. The method of any one of claims 11-14, wherein the blending step (a) is a continuous or a batch process.

16. The method of any one of claims 11-15, wherein the blending step (a) is conducted for at least 1 minute, preferably between 5 minutes and 60 minutes.

17. The method of any one of claims 11-16, wherein the method further comprises additional ingredients and wherein the fiber, the gum and the additional ingredients are blended prior to the extruding.

18. The method of any one of claims 11-17, wherein the extruding step (b) comprises extruding with a single screw extruder or a twin-screw extruder.

19. The method of any one of claims 11-18, wherein the temperature varies between 25°C to 200°C, and the pressure varies between 5-50Bar in the extruding step (b).

20. The method of any one of claims 11-19, wherein in the drying step (c) the temperature varies from about 90°C to 200°C.

21. A fiber energy composition obtained by any of the methods of claims 11-20.

22. Use of an extrusion process, to produce a fiber energy composition comprising one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

23. The use of an extrusion process as in claim 22, wherein the fibers comprise soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

24. An enriched animal feed comprising a fiber energy composition, wherein the fiber energy composition comprises a fiber/gum composition comprising one or more fibers and a gum, wherein the fiber energy composition is an extrudate, wherein the gum comprises hydratable phospholipids and lyso-phospholipids.

25. The enriched animal feed of claim 24, wherein the fiber comprises soybean hulls, rice hulls and/or combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum and/or combinations thereof, preferably the one or more fibers comprise soybean hulls and the gum comprises soybean gum.

26. The enriched animal feed of any one of the preceding claims 24-25, comprising 30wt%-90wt% of soybean hulls based on the total weight of the dry base composition.

27. The enriched animal feed of any one of the preceding claims 24-26, comprising about 5-50wt% of gum based on the total weight of the dry base composition.

28. The enriched animal feed of any one of the preceding claims 24-27, further comprising one or more additional ingredients selected from the group comprising antioxidants, grains, minerals, enzymes, wherein the amount of one or more additional ingredients is between about 1-25wt% based on the total weight of the dry base composition.

29. The enriched animal feed of any one of the preceding claims 24-28, wherein the gum comprises phosphatidylcholine (PC) phosphatidyl serine (PS), phosphatidic acid (PA), phosphatidyl choline (PC), phosphatidyl ethanolamine (PE), phosphatidyl inositol (PI), lyso-phosphatidylcholine (LPC) or any combinations thereof.

30. The enriched animal feed of any one of the preceding claims 24-29, wherein the animal feed comprises the fiber/gum composition at an inclusion rate of between 1wt% and about 20wt%.

31. The enriched animal feed of any one of the preceding claims 24-30, wherein the animal feed is an additive, a premix, a ration or combination thereof.

32. The enriched animal feed of any one of the preceding claims 24-31, wherein the animal feed is a swine feed, an equine feed, a pet food, a ruminant feed or combinations thereof.

33. The enriched animal feed of any one of the preceding claims 24-32, wherein the animal feed is a swine feed and the inclusion rate is between about 2.5wt% and about 10wt%.

34. A method for feeding an animal, comprising providing a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

35. The method for feeding an animal according to claim 34, wherein the one or more fibers comprise soybean hulls, rice hulls, corn hulls, sugar cane bagasse, palm kernel expellers, cane, rapeseed meal, canola meal, almond hulls, wheat bran, wheat middlings, wood shavings, corn husks, corn cobs, alfalfa, straw, sugar cane bagasse, sunflower meal, hay, soybean crop impurities, grain crop impurities, beet pulp, citrus pulp, palm kernel meal without husks, corn meal (hulls), corn meal (germ), cottonseed, peanuts, seaweed, castor, camelina, carinata, macaw, grass(general) and tomato meal or any combinations and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof

36. The method for feeding an animal according to claim 35, wherein the animals comprise ruminants, swine, equine, dogs, cats or any combinations thereof.

37. The method for feeding an animal according to any one of the claims 34-36, wherein the fiber/gum composition comprises soybean hulls and soybean gum.

38. The method for feeding an animal according to any one of the claims 34-37, wherein the animal is provided an animal feed comprising the fiber energy composition at an inclusion rate of between about 2wt% up 15 wt%, preferably between 3wt to 10wt%%, more preferably between 5 – 8wt%.

39. A method for feeding swine comprising providing a fiber/gum composition to the swine, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the

gum comprises hydratable phospholipids and wherein the fiber energy composition is an extrudate.

40. The method for feeding swine according to claim 39, wherein the fiber comprises soybean hulls, rice hulls or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof.

41. The method for feeding swine according to any one of the claims 39-40, wherein the swine are piglets and/or lactating sows.

42. The method for feeding swine according to any one of the claims 39-41, wherein the animal is provided an enriched animal feed comprising the fiber energy composition at an inclusion rate of between about 2wt% up 15 wt%, preferably between 3wt to 10wt%%, or preferably between 5 – 10wt%, or preferably 7.5wt%.

43. The method for feeding swine according to any one of the claims 39-42, wherein the fiber energy composition is provided to the lactating sows from farrowing until weaning or any range there between.

44. The method for feeding swine according to any one of the claims 39-43, wherein the fiber energy composition is provided to the piglets from about day 28 of life to about day 65 of life.

45. The method for feeding swine according to any one of the claims 39-44, wherein the fiber energy composition is provided at least once a day.

46. The method for feeding swine according to any one of the claims 39-45, wherein the amount of the fiber energy composition provided to the piglet is between about 20g/piglet/day and 70g/piglet/day and/or wherein the amount of fiber energy composition provided to the sow is between about 200g/sow/day and 700g/sow/day.

47. A method for feeding an equine, comprising providing a fiber energy composition to an equine animal, wherein the fiber energy composition comprises a fiber/gum composition to the equine animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

48. The method for feeding an equine according to claim 47, wherein the fiber energy composition is provided in the equine feed at an inclusion rate of between about 4wt% to 12wt% and/or wherein the amount of the fiber energy composition provided to the equine is between about 1000g/horse/day and about 2000g/horse/day.

49. A method for feeding a ruminant, comprising providing a fiber energy composition to a ruminant, wherein the fiber energy composition comprises a fiber/gum composition to the ruminant, wherein the fiber energy composition comprises a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

50. The method for feeding a ruminant according to claim 49, wherein the fiber energy composition is provided in the ruminant feed at an inclusion rate of between about 4wt% to 12wt%.

51. A method for feeding a pet, comprising providing a fiber energy composition to a pet, preferably the pet is a dog and/or a cat, wherein the fiber energy composition comprises a fiber/gum composition to the pet, wherein the fiber energy composition comprises a fiber/gum composition to the animal, wherein the fiber/gum composition comprises one or more fibers and a gum, wherein the fiber/gum composition is an extrudate, wherein the fiber comprises soybean hulls, rice hulls, or any combinations thereof and the gum comprises soybean gum, rapeseed gum, sunflower gum or any combinations thereof, wherein the fiber/gum composition comprises about 30wt%-90wt% of soybean hulls, based on the total weight of the dry base composition and about 5-50wt% of gum, based on the total weight of the dry base composition.

52. The method for feeding a pet according to claim 51, wherein the fiber energy composition is provided in the equine feed at an inclusion rate of between about 5wt% to 10wt% and/or wherein the amount of the fiber energy composition provided to the dog is about 20g/dog/day and about 70g/dog/day based on a 60lb dog and/or wherein the amount of the fiber energy composition provided to the cat between about 10g/cat/day and about 25g/cat/day.

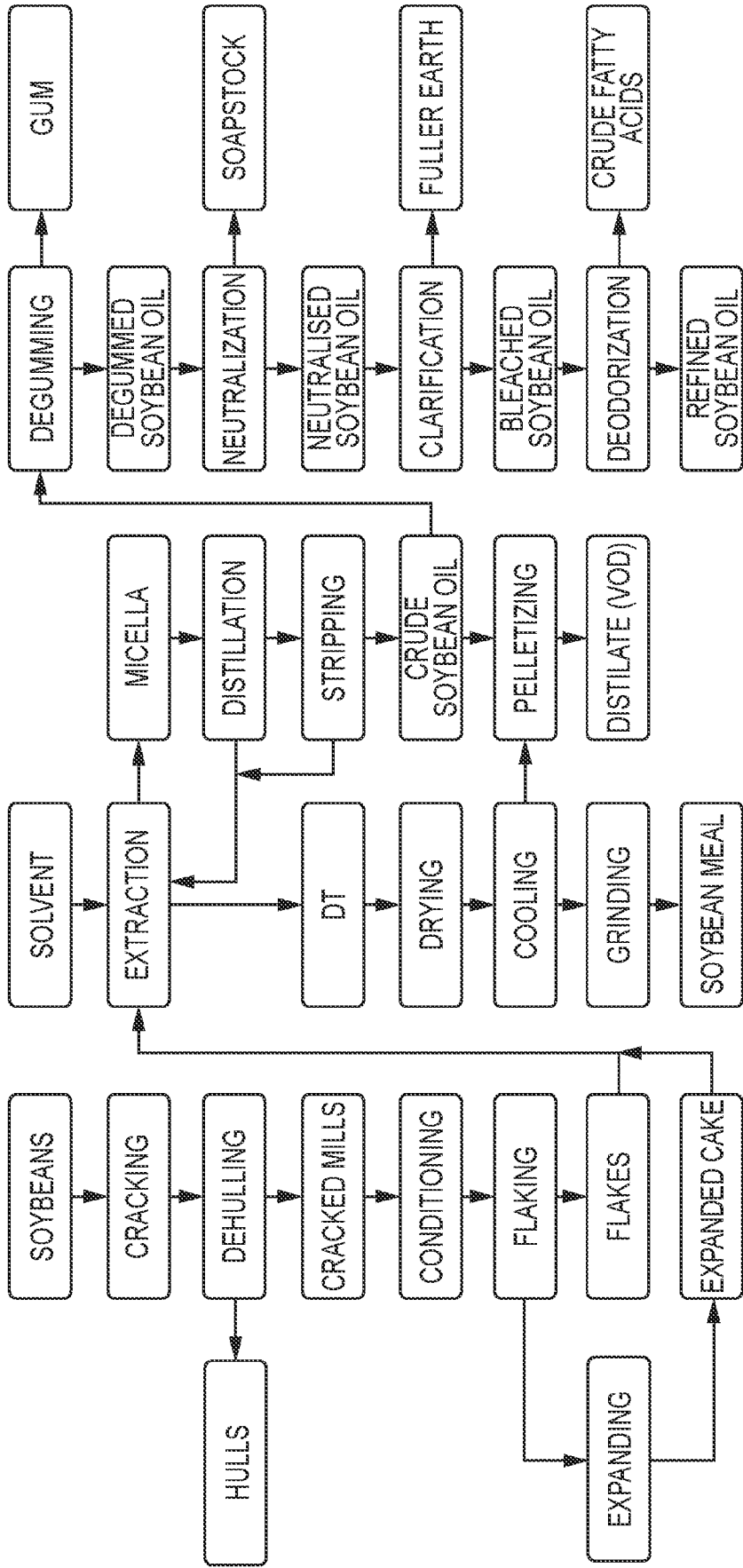


FIG. 1

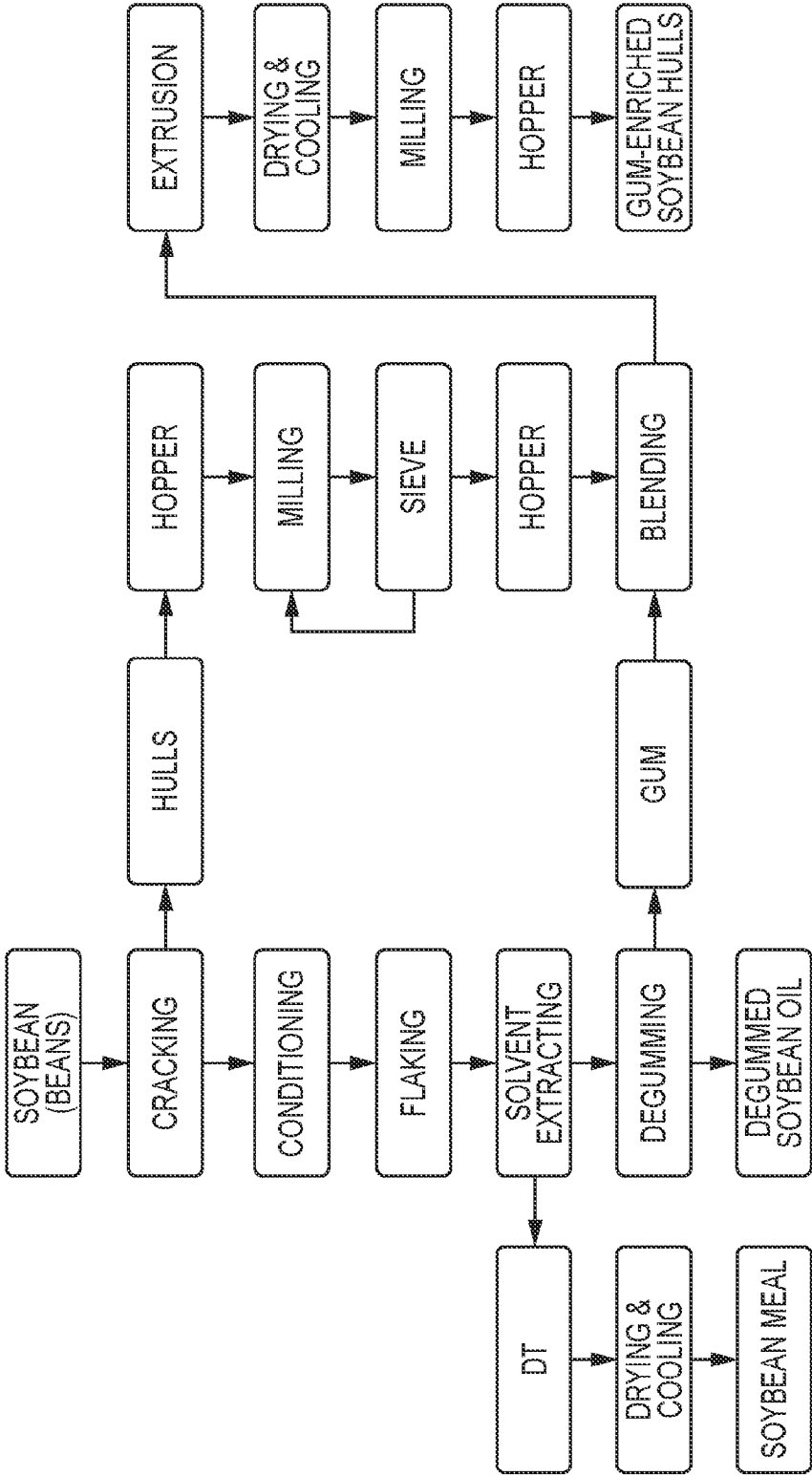


FIG. 2

3/4

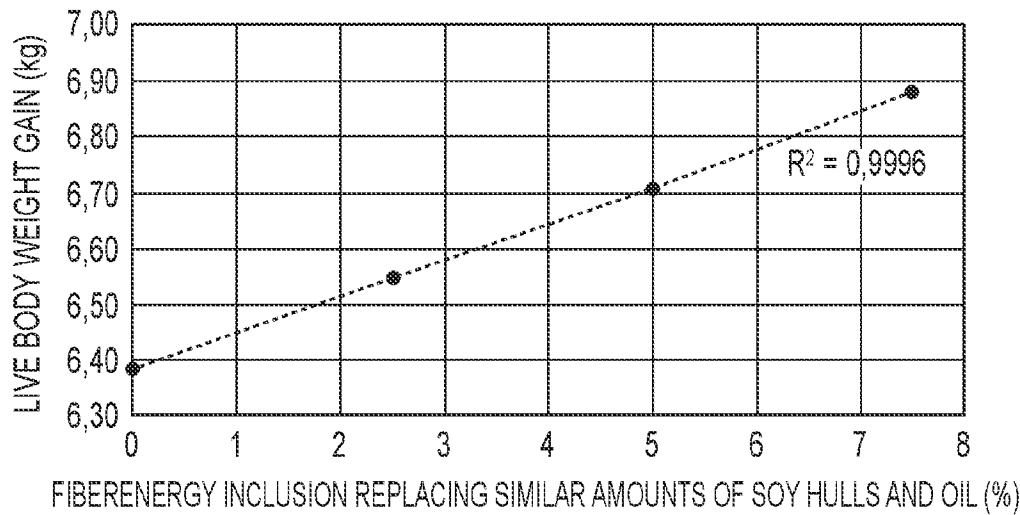


FIG. 3

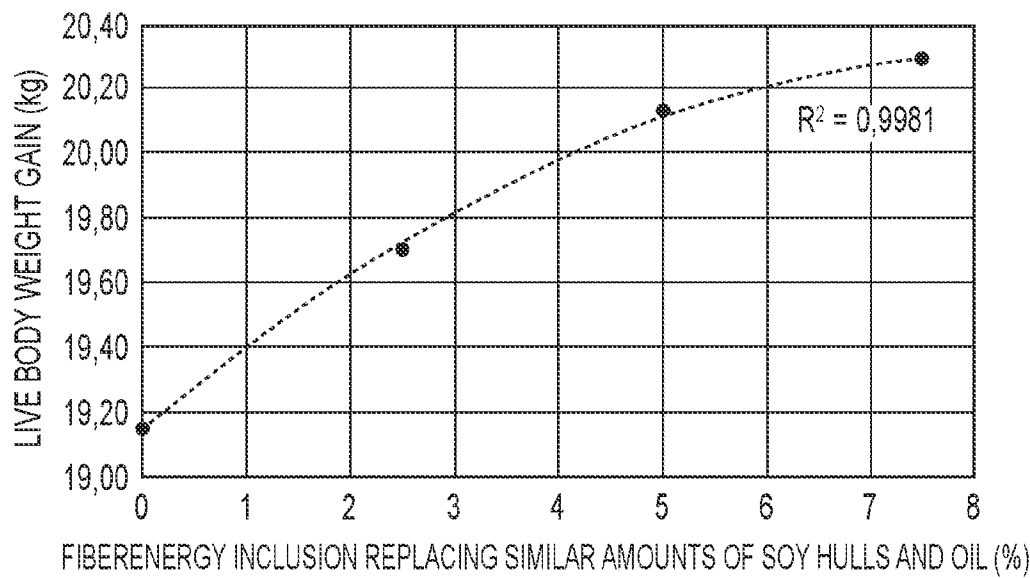


FIG. 4

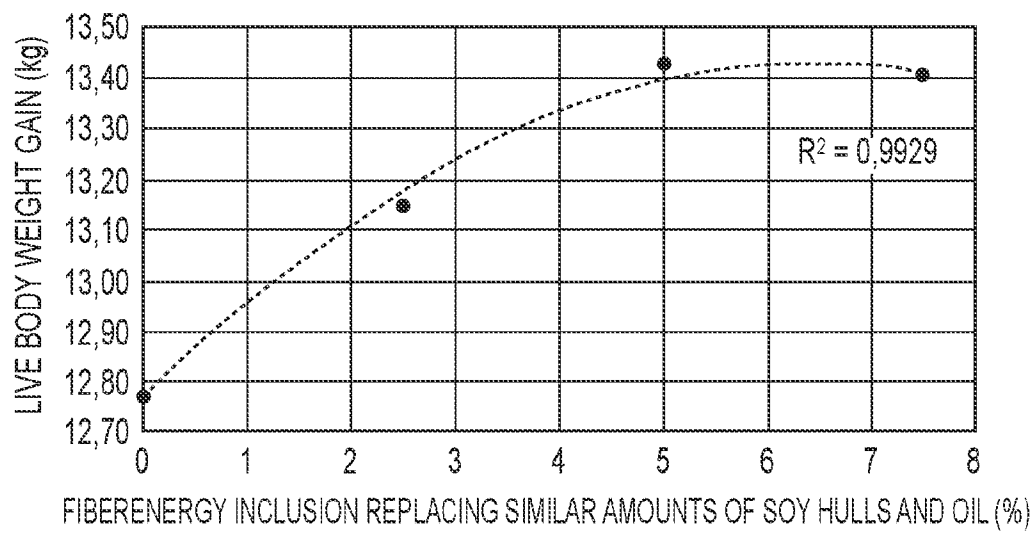


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/030339

A. CLASSIFICATION OF SUBJECT MATTER							
INV.	A23K10/30	A23K20/10	A23K40/25	A23K50/30	A23K50/10		
	A23K50/20	A23K50/40					
ADD.							
According to International Patent Classification (IPC) or to both national classification and IPC							
B. FIELDS SEARCHED							
Minimum documentation searched (classification system followed by classification symbols) A23K							
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched							
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal							
C. DOCUMENTS CONSIDERED TO BE RELEVANT							
Category*	Citation of document, with indication, where appropriate, of the relevant passages				Relevant to claim No.		
X	LICHOVNIKOVA M ET AL: "The effect of the extrusion process on the digestibility of feed given to laying hens", ANIMAL FEED SCIENCE AND TECHNOLOGY, ELSEVIER, AMSTERDAM, NL, vol. 116, no. 3-4, 15 October 2004 (2004-10-15), pages 313-318, XP004573578, ISSN: 0377-8401, DOI: 10.1016/J.ANIFEEDSCI.2004.07.018 the whole document ----- - / - -				1-52		
<table><tr><td>☒ Further documents are listed in the continuation of Box C.</td><td>☒ See patent family annex.</td></tr></table>						☒ Further documents are listed in the continuation of Box C.	☒ See patent family annex.
☒ Further documents are listed in the continuation of Box C.	☒ See patent family annex.						
<table><tr><td>* 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</td><td>"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</td></tr></table>						* 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
* 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 27 August 2024			Date of mailing of the international search report 13/09/2024				
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016			Authorized officer Graham, Judith				

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2024/030339

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LARDY G P ET AL: "EFFECT OF INCREASING THE DIETARY LEVEL OF RAPESEED MEAL ON INTAKE BY GROWING BEEF STEERS", JOURNAL OF ANIMAL SCIENCE, AMERICAN SOCIETY OF ANIMAL SCIENCE, US, vol. 72, 1 January 1994 (1994-01-01), pages 1936-1942, XP002943148, ISSN: 0021-8812 the whole document -----	1-52
X	US 8 632 833 B2 (GRIFFIN MARK [US]; LANTER KENT [US]; PURINA ANIMAL NUTRITION LLC [US]) 21 January 2014 (2014-01-21) example 1 -----	1-52
X	CN 108 850 651 A (BENGBU ZONGWA CHICKEN BREEDING FARMERS SPECIALIZED COOP) 23 November 2018 (2018-11-23) examples 1-3 -----	1-52
X	CN 108 308 428 A (ANHUI TIANBANG FEED TECH CO LTD) 24 July 2018 (2018-07-24) examples 1-3 -----	1-52
Y	CN 115 736 113 A (JIANGSU HUIFU GREASE TECH CO LTD) 7 March 2023 (2023-03-07) the whole document -----	1-52
Y	SCHWARZER K ET AL: "THE INFLUENCE OF SPECIFIC PHOSPHOLIPIDS AS ABSORPTION ENHANCER IN ANIMAL NUTRITION", FETT - LIPID.FAT SCIENCE TECHNOLOGY, WILEY-VCH VERLAG, WEINHEIM, DE, vol. 98, no. 9, 1 September 1996 (1996-09-01), pages 304-308, XP000626370, ISSN: 0931-5985, DOI: 10.1002/LIPI.19960980905 the whole document -----	1-52
X	METWALLY ABDALLAH E. ET AL: "Are the energy matrix values of the different feed additives in broiler chicken diets could be summed?", BMC VETERINARY RESEARCH, vol. 16, no. 1, 15 October 2020 (2020-10-15), XP093014075, DOI: 10.1186/s12917-020-02600-3 Retrieved from the Internet: URL:https://link.springer.com/article/10.1186/s12917-020-02600-3/fulltext.html> table 4 ----- -/-	1-52

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2024/030339

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	BINGKUN ZHANG ET AL: "Effect of fat type and lysophosphatidylcholine addition to broiler diets on performance, apparent digestibility of fatty acids, and apparent metabolizable energy content", ANIMAL FEED SCIENCE AND TECHNOLOGY, ELSEVIER, AMSTERDAM, NL, vol. 163, no. 2, 13 October 2010 (2010-10-13), pages 177-184, XP028128449, ISSN: 0377-8401, DOI: 10.1016/J.ANIFEEDSCI.2010.10.004 [retrieved on 2010-10-20] table 1 -----	1-52

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/030339

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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