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**HEMICELLULASE SUPPLEMENT TO
IMPROVE THE ENERGY EFFICIENCY OF
HEMICELLULOSE-CONTAINING ANIMAL
FEED**

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is a continuation of application Ser. No. 07/529,327, filed May 29, 1990, now abandoned.

BACKGROUND OF THE INVENTION

Different enzymes are categorized as a specific type of hemicellulase—a glucanase, a xylanase or a mannanase, for example—based on an ability to catalyze the hydrolysis of heteropolysaccharides composed of glucan, xylan or mannan, respectively. It is known that enzymes that effect hydrolysis of mannans, such as a galactan or a glucomannan, are produced by various microorganisms, including bacteria and fungi, and that they also occur in some animals and in numerous plants. Among the microorganisms that produce such mannanases are species of *Aeromonas*, *Aspergillus*, *Streptomyces*, *Rhodococcus* and *Bacillus*. See 160 METHODS IN ENZYMOLOGY Part A, Sect. II (1988).

Hemicellulases have been employed commercially in the processing of coffee, chocolate, cocoa, tea and cereals. The primary advantage gained by using a hemicellulase in this regard is a reduction in solution viscosity which allows for more inexpensive processing of food products. Thus, hemicellulases are used to clarify fruit juices, to reduce the viscosity of slurries or purees, to liquefy certain cell wall solids, and to modify taste. But if the available energy content of human food and animal feed products could be increased, particularly in animal feed, there would be opportunities for cost savings. The successful use of glucanase-treated barley as a corn substitute in avian diets is one such example. See *Feedstuffs* 62: 10 (1990).

Hemicellulosic materials such as alfalfa, coconut residue, guar, locust bean gum, carob bean gum, cassava, copra and soybeans are common constituents of food and feed products. Soybean derivatives comprise a substantial proportion of the ingredients of tofu for human consumption, for example, and soybean protein is used in many feeds for dogs and cats, swine, fish and chickens. Soybean meal may comprise as much as 25% of the feed for baby chickens. The feed rations for chickens, such as broilers, are complex mixtures, formulated from a number of components on a least cost basis. The rations are required in very large volumes. As a result, costly storage facilities for the feed components are necessary for the blending operations. The feed components are blended to provide an optimal nutritional mixture of protein, essential amino acids, minerals, vitamins and calories (that is, an energy source). Soybean meal has been found to be a preferred concentrated source of protein with amino acids and, while not considered a primary energy source such as yellow corn, it supplies about 20% of the energy requirements of broiler chickens.

Although soybean meal provides some carbohydrates and oils which yield energy, approximately 10% of its total carbohydrate content is comprised of galactans and pentosans. These carbohydrates are not absorbed to any appreciable degree by monogastric animals as the animals are unable to digest them rapidly enough to obtain the appropriate monosaccharide for further biochemical oxidation. One approach to increasing the energy content of soybean

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meal would be to reduce the galactans and pentosans to low molecular weight oligosaccharides or monosaccharides like glucose or similar carbohydrate components which can be more easily metabolized by monogastric animals.

A need therefore exists for a way to increase the available energy content of the hemicellulosic component of food and feedstuffs by converting mannan-containing hemicellulose components therein into lower molecular weight carbohydrates which can be metabolized by monogastric animals.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a hemicellulase-containing composition that, because it also contains a novel hemicellulase, has an enhanced energy content when consumed.

It is also an object of the present invention to provide a method of producing nutritive materials that contain complex carbohydrates but that nevertheless are usable by a human or monogastric animal.

In accomplishing these and other objects, there has been provided, in accordance with one aspect of the present invention, a consumable composition comprising (A) protein, vitamins and minerals nutritionally suitable for a monogastric animal or a human; (B) a source of carbohydrates, comprising a mannan-containing hemicellulose; and (C) an enzyme that catalyzes the degradation of said mannan-containing hemicellulose, wherein the enzyme has a pH profile for its activity in catalyzing said degradation that ranges from about pH 4.5 to about pH 11. In a preferred embodiment, the consumable composition is for human consumption, i.e., its constituents meet applicable regulatory requirements for human food, as opposed to animal feeds. In another preferred embodiment, by contrast, the composition is for a monogastric animal and, hence, need meet only those requirements which apply to animal feeds.

In accordance with another aspect of the present invention, a composition containing the above-described components described has been provided that includes, as component (C), an enzyme that is active in catalyzing the degradation of mannan-containing hemicellulose under conditions where both (1) pH is in the range of 8–11 and (2) temperature is at least 60° C.

In accordance with still another aspect of the present invention, a consumable composition is provided that comprises soybean meal and an enzyme component that consists essentially of a *Bacillus* hemicellulase having a pH profile, relative to its activity in catalyzing degradation of hemicellulose, that ranges from about pH 4.5 to about pH 11. In one preferred embodiment, the aforementioned pH profile peaks between about pH 7 and about pH 9.

In accordance with yet another aspect of the present invention, a nutritive method has been provided that comprises the steps of (A) preparing a consumable composition comprised of protein, vitamins and minerals nutritionally suitable for a monogastric animal or human, and further comprising a carbohydrate source comprised of mannan-containing hemicellulose; and (B) incorporating into that composition an enzyme that catalyzes the degradation of the mannan-containing hemicellulose, wherein the enzyme has a pH profile for its activity in catalyzing said degradation that ranges from about pH 4.5 to about pH 11, such that said enzyme renders the mannan-containing portion of said hemicellulose usable by a monogastric animal or a human. In a preferred embodiment, the aforementioned source of carbohydrates is vegetable matter selected from the group consisting of soybeans, alfalfa, guar, locust bean gum, carob