

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Protein Food Product and Process

We, ARCHER DANIELS MIDLAND COMPANY, a Corporation of the State of Delaware, United States of America, of 733, Marquette Avenue, Minneapolis, Minnesota 55440,

5 United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to the production of meat-like food products from vegetable, fish and similar protein sources. More particularly, the present invention relates to the production of protein structures having a texture and appearance very similar to muscle protein found in common meat products like steaks, fowl, chops, hams and the like.

15 The preparation of meat-like food products from other protein sources has long been an aim of the food industry. Heretofore, food technologists have relied in many instances on the art developed in the production of synthetic fibres for the textile industry to produce meat-like products from other protein sources which simulate the fibrous chewing quality of meat. Thus it has been proposed to prepare protein fibres by solution or colloidal dispersion of protein in an aqueous alkaline phase, passing such solution through a spinneret and into an acid coagulating bath and recovering and stretching the resulting fibres. The stretching is required to impart toughness or chewiness to the product. The fibres are then mixed with an edible binder which may be either physical or adhesive in nature. The final product is obtained by compounding the fibres into a tow which is then cut into suitable length and packaged.

20 In another method proposed hitherto a solution of protein is formed which is then precipitated under agitation at elevated temperature by lowering the pH of the solution. The resulting precipitate may then be

admixed with a binder and stirred into a uniform paste which can be shaped into any form desired such as strands. The resulting strands are autoclaved with steam to give rise to the final product.

Both the methods above described require the protein to be in pure or substantially pure form and hence require a separation from available protein-containing materials. Furthermore, these processes require modifiers such as binders to simulate the texture of meat and the resulting meat-like products cannot be cooked without structural disintegration.

According to the present invention there is provided a process for the production of a protein product by the extrusion of an aqueous edible protein-containing material through an orifice into the atmosphere or an inert gaseous medium at a lower pressure at a temperature above the boiling point of water at said lower pressure to result in an expanded protein-containing product of plexilamellar structure as herein defined which can also be characterised by its open cell structure in which a majority of cells have a length to diameter ratio of greater than one, the length being measured in the direction of extrusion and the diameter being measured in the transverse direction.

The invention also provides an expanded protein food product having a plexilamellar structure, as herein defined, and the majority of the open cells of which have cell dimensions of greater length than average diameter, the length of said cells being substantially aligned.

By the term "plexilamellar structure" we mean a structure which comprises a network of interlaced, interconnected ribbons or sheets of varying width and thickness.

The protein extrudate of the present invention is a tough, resilient, dry to slightly moist to the touch, open-celled foam made up of interlaced, interconnected ribbons of varying width and thickness which may appear fibrous

[Price 4s. 6d.]



in nature or may be sheet-like. The majority of the cells defined by this plexilamellar protein structure are irregular in shape but are characterized by greater length in the direction of extrusion than diameter as measured in the transverse direction. The extrudate thus obtained can be rehydrated by cooking in hot water or by subjecting it to steam. Such action will cause the extrudate to further expand and swell and give rise to a product having the texture, appearance and coherence of meat. The attached drawing, Figure 1, shows a photomicrograph of a section, cut in the machine direction, of the plexilamellar extrudate on hydration.

The process employed to form the plexilamellar protein of the present invention comprises, more specifically, admixing the protein-containing raw material with water, masticating the mixture until a homogeneous plastic mass is obtained, subjecting the plastic mass to pressure while heating it to a temperature above 200°F., and then extruding the pressure-heated mass through one or more flow-restricting orifices into a medium of lower pressure and temperature, in which the water will be released as steam. The blending of the protein raw material and the water to give rise to a uniform plastic mass may be carried out simultaneously with the heating step. Although an extremely wide variety of equipment may be employed to accomplish the aforesaid process steps, it will be apparent that extruders of the type employed in the fabrication of thermoplastic resins are eminently suited to the process of the present invention. These extruders, comprising a heated barrel, a rotating screw within the barrel and an extrusion die at the front end of the barrel, blend the protein-containing extrusion mixture, hereinafter also called the protein mix, while simultaneously heating the mixture to the desired temperature. The rotating screw builds up to the pressure required to push the plastic protein mass through the restricted orifice in the extrusion die, giving rise to the pressure differential across the die orifice required to cause the formation of the plexilamellar extrudate. The barrel in combination with the rotating screw create in effect a closed chamber which prevents the release of the steam from the protein mix until it emerges from the die. As a result of the pressure differential across the die orifice, the steam is released and causes the expansion or foaming of the protein extrudate.

Although the following explanation of the unique properties of the plexilamellar protein is not to be considered as binding, it is given for a better understanding of the novel product of the present invention. Thus it is believed that the tough resilient structure of plexilamellar protein which allows it to be cooked for long periods of time without disintegra-

tion into mush is the result of a twofold orientation occurring in the extrusion. Thus molecular orientation is induced when the protein mix is pressed through the orifice and when the extrudate is expanded by the released steam on emerging from the orifice. Since the expansion of the extrudate on emergence from the die is not limited to the direction of flow, it will be apparent that the resulting extrudate may at least in part be multiaxially oriented, and hence may be the cause of the unique properties of plexilamellar protein.

The process of the present invention is not limited to any particular type of protein. Any type of edible protein of vegetable, fish or animal origin may be employed. The preferred proteins from the standpoint of an optimum product are the oil seed proteins such as peanut, cotton seed, sesame seed, or soya bean proteins. The protein may be employed in substantially pure or water-soluble form or, as is preferred, in the form of flakes or flour, generically herein referred to as meal, obtained on solvent extraction of oils and other fatty materials. Solvent extraction of oil seeds to remove oil and other fatty materials is well known in the art and thus need not specifically be described. The protein-containing oil seed meals which have protein concentrations of 40 to 70 per cent are preferred since they can be extruded into the plexilamellar product of the present invention over a broad range of conditions. Protein concentrates also give rise to plexilamellar structure although the extrusion conditions are more critical. If desired, protein concentrates or protein meals may be diluted with non-proteinaceous fillers such as cereals, wheat flour or starches. The protein concentration of the material to be extruded should, however, be maintained at a level above 30%, since otherwise the added filler will interfere in the interaction of the protein molecules occurring during the extrusion and expanding step, which interaction is necessary to obtain the hydratable character of the plexilamellar protein of the present invention.

The nature of the extrudate, for any given starting material, is principally governed by the concentration of water in the protein mix, the temperature to which the protein mix is heated during the extrusion and the pressure developed in the extruder. The presence of water is essential for two reasons: it plasticizes the protein mix being extruded, and it causes the blowing of the extrudate. It therefore follows that an increase in the concentration of water will result in greater plasticization and a higher degree of expansion. However as is well known, proteins contain chemically bound water which may not be released during the extrusion. The concentration of chemically bound water is not constant and increases with decreasing extrusion temperature as well

as with increasing protein concentrations in the protein mix fed to the extruder. It will also vary with the nature of the proteinaceous starting material employed. Hence the minimum concentration of water necessary to obtain the formation of the plexilamellar extrudate will vary, but should be at least 5 to 10% above the non-releasable water concentration. If the water concentration becomes too high, the fluidity of the protein mix is too high to allow continuous extrusion and proper feeding of the protein mix. The resulting expansion may also cause a greater than desired cell structure. From the foregoing description it will be apparent that the lower concentration of water is primarily dependent on the nature and concentration of the protein in the protein mix, while the upper concentration is limited by the extrudability of the material which is a function of the extruder design. In general it was found that the total concentration of water will vary from 10 to 60% of the protein mix.

Since the expansion of the extrudate normally occurs at atmospheric pressure, the minimum temperature to which the protein mix must be heated is the boiling point of water, 212°F., in order to cause steam expansion of the extrudate. The application of a vacuum to the extrudate may, of course, allow the use of somewhat lower temperatures such as 200°F.

An increase in the extrusion temperature, other variables being maintained constant, will result in a finer celled foam, more fibrous in character. The upper limit of the extrusion temperature is dictated by the stability of the protein mix. Thus the temperature should not be so high as to cause substantial degradation of the protein or any additive being present. The extrusion temperature should, therefore, be maintained within a range of 200 to 450°F., and preferably within a range of 240 to 350°F.

The effect of pressure is difficult to establish in view of the other factors affecting the quality and nature of the extrudate. However, it will be apparent that a certain minimum pressure is necessary to force the extrudate out of the orifice and to maintain the water dissolved in the protein mix from prematurely expanding. In general, the pressure drop across the orifice should be at least 100 p.s.i. and preferably is greater than 1000 p.s.i.

A higher pressure will result in higher extrusion rates and consequently in higher shear rates which in turn result in better cohesion and retention of structure on rehydration. There is no upper pressure limit for the process of the present invention, and hence the upper limit is in general dictated by the type of equipment employed. When employing a plastics extruder, pressure may be increased by decreasing the size of the orifice,

increasing the compression ratio of the screw, or by increasing the rpm of the extruder screw. The design of the extrusion orifice is a matter of choice and may vary from a slit or band orifice to a circular or square orifice. It should only be remembered that the extrusion orifice should not be so large that the extrusion equipment cannot produce the necessary pressure differential.

Various additives may be blended into the protein mix to improve its extrusion characteristics or to alter the nature of the rehydrated extrudate with respect to texture, firmness and cohesion. Thus in general the pH of the protein mix is adjusted to be within a range of 5.0 to 8.5 and preferably within a range of 6.5 to 7.5. At pH levels below 5.5 the extrusion becomes difficult in standard extrusion equipment in view of the reduced flow of the protein mix. The rehydrated extrudate furthermore may be too rubbery from the standpoint of chewing and too sour from the standpoint of taste. Increasing the pH from this low level results in increased tenderness. A pH level above 8.5 may result in a bitter taste making the product unsuitable for consumption.

Sodium chloride may also be used as an additive. It is generally employed in concentrations of up to 3 per cent based on the protein mix. The addition of sodium chloride also increases the firmness of the rehydrated product and thus sodium chloride may be used to complement the effect of pH.

A third valuable additive is a soluble calcium salt such as calcium chloride. Calcium ions act as crosslinking agents increasing the molecular weight of the protein. Such increase in molecular weight is particularly desirable when the concentration of the protein-containing material of the composition to be extruded drops below 50 per cent. The increase in molecular weight improves the shearing action occurring during extrusion and expansion. Increased shear will result in a more fibrillated plexilamellar structure resulting in a finer texture on rehydration, and also will give rise to higher degree of firmness and chewiness. In general the concentration of the calcium salt should not exceed 3 per cent of the protein mix.

It will be appreciated that various other flavouring and colouring additives, normally added to meat-like protein products may also be added to the protein mix of the present invention prior to extrusion.

The plexilamellar extrudate emerges from the extruder as one or more continuous bands or strands. It is, in general, desirable to cut the extrudate into pellets or chunks for easier packaging, handling or storing. Depending on the extrusion conditions employed, a substantially dry or slightly moist extrudate is obtained. From the standpoint of storage and transportability, it is desirable to dry the



moist extrudate prior to packaging. The rehydration of the plexilamellar extrudate is readily achieved by contact with water, preferably at elevated temperatures. Thus, the dried extrudate may be simmered or pressure cooked in water and readily swells and expands to result in a texture similar to that of meat. The texture of the rehydrated extrudate can be varied to assume the structures of known meat products by changing the extrusion conditions, particularly extrusion temperatures, and the nature and amount of additives such as pH agents and calcium salts. Higher temperatures, lower pH and addition of calcium chloride can change the texture of the rehydrated product; for example, from that of chicken meat to that of beef. The invention is further illustrated by the following examples:

EXAMPLE I

The following components listed in the order of their addition were mixed in a ribbon blender at 120°F. for about 20 minutes:

11350 g. of extracted soya bean flakes prepared according to U.S.A. Patent No. 3,100,709 containing 50% soya bean protein and 6.5% moisture;

45 ml. of 50% hydrogen peroxide for purposes of flavour and odour control diluted in 380 ml. of water;

1700 g. of imitation beef seasoning;

3785 ml. of water;

90 g. of 97% pure sodium hydroxide; and

340 g. of calcium chloride dissolved in 500 ml. of water.

The resulting composition contained 30% moisture and 3% calcium chloride, and was extruded in a "Prodex" (Registered Trade Mark) 1½ inch extruder equipped with a medium compression screw and an extrusion die containing eight 3/16 inch diameter orifices. The extruder was maintained at a temperature of 350°F., at the extrusion die and the front end of the barrel. The screw was rotated at a rate of 176 r.p.m.

The product expanded rapidly on emerging from the die while releasing steam. Substantially dry plexilamellar protein strands were obtained which were cut into 0.5 inch lengths by a rotating knife. The resulting product was autoclaved at 15 p.s.i. steam for 60 minutes. The rehydrated product resembled beef in appearance and had firm and chewy eating characteristics.

EXAMPLE II

The following components listed in the order of their addition were mixed in a ribbon blender at 120°F. for about 20 minutes:

11350 g. of the extracted soya bean flakes of Example I containing 50% soya bean protein and 6.5% moisture;

3340 ml. of water;

35 g. of 97% pure sodium hydroxide; and

115 g. of sodium chloride dissolved in 600 ml. of water.

The resulting composition contained 30% moisture, had a pH of 6.5, and was extruded in the extruder described in Example I. The extruder was maintained at a temperature of 250°F. at the extrusion die and the front end of the barrel. The screw was operated at 176 r.p.m. and the pressure developed at the front end of the extruder was 1750 p.s.i. The dried plexilamellar extrudate absorbed 3.65 g. of water per g. of dry extrudate, was white in colour, fibrous in appearance and resembled dried chicken meat. The rehydrated, unflavoured product was firm to slightly chewy and bland in flavour.

EXAMPLE III

Employing the procedure of Example II, a blend of the soya bean flakes of Example I, 1% sodium chloride, 1% calcium chloride and 30% moisture, having a pH of 6.15, was extruded at a temperature of 275°F. The extrudate was tough and strongly fibrillated. The dried product was simmered in water, retained its shape, and had a fibrous texture. Extrusion of the same material at 105°F. resulted in an unfoamed soft, gel-like, amorphous extrudate which completely disintegrated on simmering in water.

EXAMPLE IV

Following the procedure of Example II, a blend of a soya bean flake containing 70% soya bean protein, 1% sodium chloride, and 35% moisture, having a pH of 6.9, was extruded at 260°F. Steam evolution at the orifice caused considerable expansion and resulted in a plexilamellar extrudate. On simmering in water, the extrudate had a chewy meat-like texture. Extrusion of the same composition at 140°F. resulted in a weak extrudate that was not expanded. The material completely cooked apart on simmering.

EXAMPLE V

The soya bean flake composition of Example I containing 50% water was extruded at a temperature of 325°F. using the procedure of Example II. Feed and extrusion were difficult to maintain continuously in view of the limitations of the equipment employed. The extrudate, however, was plexilamellar in structure and could be rehydrated into a firm texture without disintegration.

Similar results are obtained if instead of the soya bean flakes used in the foregoing examples, a soya bean protein obtained by isoelectric point precipitation of protein solubilized from soya bean flakes, whale flour produced by the solvent extraction of whale meat, solvent extracted peanut meal, ground

aqueous edible-protein
containing material



nut meal, cottonseed meal, or commercial casein is employed.

The present invention provides a meat-like product having the texture, appearance and seating characteristics of meat. It is readily produced on a continuous basis and can be packaged, handled and stored in the dry form without requiring canning. On rehydration, the product can be boiled, fried, roasted, and steamed without loss of shape or texture. The versatility of the process of the present invention allows the formation of a wide variety of edible products of differing texture without destroying the unique characteristic of the product of the present invention; namely, its retention of texture and shape on rehydration. The flexibility of the process of the present invention also allows the addition of modifiers without changing the basic nature of the product. It is eminently suited for the conversion of inexpensive, impure proteins, e.g., soya bean meal, into highly attractive meat-like products of high nutritional value.

WHAT WE CLAIM IS:—

1. A process for the production of a protein product which comprises extruding and through an orifice into the atmosphere or an inert gaseous medium at a lower pressure than that in the extruding device at a temperature above the boiling point of water at the pressure in the receiving vessel so that an expanded protein-containing product of plexilamellar structure as herein defined is obtained in which a majority of the cells have a length to diameter ratio greater than one, the length being measured in the direction of extrusion and the diameter in the transverse direction.
2. A process as claimed in claim 1 in which the product is further expanded by treatment with hot water or steam to give the appearance and coherence of meat.
3. A process as claimed in claim 1 or claim 2 in which before extruding, the protein-containing raw material is mixed with water and masticated until a homogeneous plastic mass is obtained which is heated under pressure to a temperature above 200°F.
4. A process as claimed in any one of the preceding claims in which the protein-containing material is an oil-seed protein, in the form of meal obtained on the solvent extraction of oils and other fatty materials from said oil-seed material.
5. A process as claimed in claim 4 in which the oil-seed material is peanut, cottonseed, sesame seed or soya bean.
6. A process as claimed in claim 4 or claim 5 in which the oil seed meal has a protein content of 40 to 70 percent.
7. A process as claimed in any one of the preceding claims in which the extrusion temperature is maintained within the range of 200° to 450°F.

8. A process as claimed in any one of the preceding claims in which the pressure across the orifice of the extruding device is at least 1000 p.s.i. 65

9. A process as claimed in any one of the preceding claims in which the pH of the protein mix is adjusted to between 5.0 and 8.5. 70

10. A process as claimed in claim 9 in which the pH is adjusted to between 6.5 and 7.5. 75

11. A process as claimed in claim 1 for the production of a protein product substantially as described in any one of the specific Examples herein.

12. A protein-containing product when prepared by the process claimed in any one of the preceding claims. 80

13. An expanded protein food product having a plexilamellar structure, as herein defined, and the majority of the open cells of which have cell dimensions of greater length than average diameter, the length of said cells being substantially aligned. 85

14. An expanded protein food extrudate having a plexilamellar structure as herein defined in which the majority of cells have cell dimensions of greater length than average diameter, the length being measured in the direction of extrusion, the diameter being measured in the transverse direction. 90

15. An expanded protein food extrudate as claimed in claim 13 or claim 14 and being capable of hydration and withstanding boiling in water. 95

16. A food product as claimed in any of claims 13 to 15 in which the protein employed is a vegetable protein. 100

17. A food product as claimed in claim 16 in which the protein employed is an oil seed protein. 105

18. A product as claimed in claim 17 in which the oil seed protein is an oil seed meal.

19. A product as claimed in claim 17 in which the oil seed protein employed is soy protein. 110

20. A product as claimed in claim 19 in which the soy protein is in the form of soy meal.

21. A product as claimed in any of claims 13 to 20 having a protein concentration of at least 30 percent based on the solids content of the product. 115

22. A product as claimed in any of claims 13 to 21 in hydrated form. 120

23. A product as claimed in claim 13 substantially as herein described with reference to any one of the Examples.

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nut meal, cottonseed meal, or commercial casein is employed.

The present invention provides a meat-like product having the texture, appearance and seating characteristics of meat. It is readily produced on a continuous basis and can be packaged, handled and stored in the dry form without requiring canning. On rehydration, the product can be boiled, fried, roasted, and steamed without loss of shape or texture. The versatility of the process of the present invention allows the formation of a wide variety of edible products of differing texture without destroying the unique characteristic of the product of the present invention; namely, its retention of texture and shape on rehydration. The flexibility of the process of the present invention also allows the addition of modifiers without changing the basic nature of the product. It is eminently suited for the conversion of inexpensive, impure proteins, e.g., soya bean meal, into highly attractive meat-like products of high nutritional value.

WHAT WE CLAIM IS:—

1. A process for the production of a protein product which comprises extruding and through an orifice into the atmosphere or an inert gaseous medium at a lower pressure than that in the extruding device at a temperature above the boiling point of water at the pressure in the receiving vessel so that an expanded protein-containing product of plexilamellar structure as herein defined is obtained in which a majority of the cells have a length to diameter ratio greater than one, the length being measured in the direction of extrusion and the diameter in the transverse direction.

2. A process as claimed in claim 1 in which the product is further expanded by treatment with hot water or steam to give the appearance and coherence of meat.

3. A process as claimed in claim 1 or claim 2 in which before extruding, the protein-containing raw material is mixed with water and masticated until a homogeneous plastic mass is obtained which is heated under pressure to a temperature above 200°F.

4. A process as claimed in any one of the preceding claims in which the protein-containing material is an oil-seed protein, in the form of meal obtained on the solvent extraction of oils and other fatty materials from said oil-seed material.

5. A process as claimed in claim 4 in which the oil-seed material is peanut, cottonseed, sesame seed or soya bean.

6. A process as claimed in claim 4 or claim 5 in which the oil seed meal has a protein content of 40 to 70 percent.

7. A process as claimed in any one of the preceding claims in which the extrusion temperature is maintained within the range of 200 to 450°F.

8. A process as claimed in any one of the preceding claims in which the pressure across the orifice of the extruding device is at least 1000 p.s.i.

9. A process as claimed in any one of the preceding claims in which the pH of the protein mix is adjusted to between 5.0 and 8.5.

10. A process as claimed in claim 9 in which the pH is adjusted to between 6.5 and 7.5.

11. A process as claimed in claim 1 for the production of a protein product substantially as described in any one of the specific Examples herein.

12. A protein-containing product when prepared by the process claimed in any one of the preceding claims.

13. An expanded protein food product having a plexilamellar structure, as herein defined, and the majority of the open cells of which have cell dimensions of greater length than average diameter, the length of said cells being substantially aligned.

14. An expanded protein food extrudate having a plexilamellar structure as herein defined in which the majority of cells have cell dimensions of greater length than average diameter, the length being measured in the direction of extrusion, the diameter being measured in the transverse direction.

15. An expanded protein food extrudate as claimed in claim 13 or claim 14 and being capable of hydration and withstanding boiling in water.

16. A food product as claimed in any of claims 13 to 15 in which the protein employed is a vegetable protein.

17. A food product as claimed in claim 16 in which the protein employed is an oil seed protein.

18. A product as claimed in claim 17 in which the oil seed protein is an oil seed meal.

19. A product as claimed in claim 17 in which the oil seed protein employed is soy protein.

20. A product as claimed in claim 19 in which the soy protein is in the form of soy meal.

21. A product as claimed in any of claims 13 to 20 having a protein concentration of at least 30 percent based on the solids content of the product.

22. A product as claimed in any of claims 13 to 21 in hydrated form.

23. A product as claimed in claim 13 substantially as herein described with reference to any one of the Examples.

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containing material