Milk protein fibers are produced by an extrusion process for the textile industry inter alia, in which at least one thermoplasticizable protein obtained from milk is plasticized with a plasticizer, for example water or glycerol, at temperatures between room temperature and 140° C., under mechanical stress and spun to fibers by means of a jet.
PROCESS FOR PRODUCING MILK PROTEIN FIBERS AND MILK PROTEIN FIBER PRODUCTS OBTAINED THEREFROM

[0001] The invention relates to a method for producing milk protein fibers, inter alia for the textile industry and hygiene and medical products, and to the associated milk protein fiber products such as cotton wools, fleeces, loose short fibers, yarns, woven and knitted fabrics as well as other products manufactured by means of the fiber according to the invention.

STATE OF THE ART

[0002] Milk protein fibers belong to the protein fibers which in the widest sense also include the natural products wool and silk. Protein fibers have been known for a long time on the technical scale. Casein fibers were already produced in the thirties. Casein is a protein fraction from the milk of mammals. Casein is produced from skimmed milk which is brought to coagulation at 45°C by means of acids at around pH 4.6 (the isoelectric point of casein). Alternatively, lab is used for the coagulation. The solid matters are separated or pressed off and washed several times. Finally, a drying at 50 to 80°C is carried out to obtain a residual water content of less than 10% (Röhm Chemielexikon, Georg-Thieme-Verlag, 1989 under “casein”). Casein is a mixture of several proteins of which the most important ones are generally designated as αs1, αs2, β and κ (cow’s milk). Since the white to yellowish, slightly hygroscopic casein powder is insoluble in water, but soluble in alkalies, it is required for the classical way of manufacturing by the solution spinning process to work in the alkaline environment and to subject the fiber to other treatment steps and baths afterwards. The proteins are dissolved in alkalies, filtered, cleaned, pressed through jets into an acid bath, drawn and hardened with formaldehyde or ammonium sulfate (Röhm reference as above).

[0003] In the classical wet spinning processes, an aqueous casein solution is set at a pH value of 7 to 10 by means of sodium carbonate, agitated at room temperature over 24 hours and degassed in vacuum before a further processing. The solution is then extruded into a coagulation bath which contains aluminum sulfate-octadecylamine, sodium chloride and sulfuric acid. Afterwards, the milk fiber will be hardened over 24 hours in a hardening bath by means of sodium acetate-triethylamine and formic acid solution at a pH value of 5.5. The fiber will then be cleared of residues of the hardening bath under running water over 24 hours and dried at room temperature. The pollution level provoked by the coagulation bath and the consumption of water are very high. Furthermore, this method requires a lot of time, the process time is about 60 hours.

[0004] From DE PS 905 418 hardening baths are for example known which correspond to the above statements.

[0005] EP 0 051 423 A2 describes a method for the preparation of a material that contains casein. Accordingly, a plastic mass made of water and a protein is extruded into a gas atmosphere by means of an extruder. In this method it is important that the extrusion takes place at a temperature of 100°C, whereas the material to be heated up within the scope of a post-treatment.

[0006] This leads to longer production times and an additional energy demand.

[0007] Concerning the above known method, the end product shall be used in the field of food. For this reason, exclusively proteins are disclosed as classification substances, i.e. in particular gluten as well as sources such as fish and meat are mentioned. The thus obtained products are water soluble and have no significant tensile strength.

OBJECT OF THE INVENTION

[0008] It is the object of the invention to avoid the above mentioned disadvantages and to shorten the processing time. At the same time, the water and energy consumption shall be decreased.

Solution According to the Invention

[0009] The problem is solved by the method according to claim 1. Herein, at least one protein obtained from milk is plasticized together with a plasticizer at temperatures comprised between room temperature and 140°C. Under mechanical stress and is spun to fibers through a jet, wherein the plasticizer is selected from the group: aqueous polysaccharide solution, alcohol, polyalcohol or mixtures of these substances.

[0010] According to the invention, it is proposed to use alcohol or polysaccharide as plasticizer. Thanks to the use of these newly proposed plasticizers, it is possible to produce a milk protein fiber which does not comprise the disadvantages of the state of the art.

[0011] The invention is based upon the knowledge that the milk proteins and in particular casein can be plasticized in the heat by kneading and thus be processed in the melt spinning process. In the melt spinning process, the dried meltable raw material is thermally plasticized and preferably pressed as melt through jets by means of gear pumps or extruders. The melt solidifies after extrusion. The drawn-out thread is wound up or further processed as desired. The drawn-out threads can be drawn or also surface-treated before being wound up.

[0012] For achieving an even more gentle treatment, the protein is intensely mixed or kneaded with a plasticizer and simultaneously subjected to mechanical stress.

[0013] The milk protein is preferably casein or lactalbumin.

[0014] The milk protein obtained from milk can be produced in situ by precipitation from milk. According to a first procedure, the milk in form of a mixture with lab, other suitable enzymes or acid can be immediately introduced into the process as flocculated mixture or the pressed-off flocculated protein can be used in humid form. According to another optional procedure, a previously separated obtained, if necessary prepared, pure or mixed protein, i.e. a protein fraction from milk, can be used. For example in the form of a dried powder.

[0015] The milk protein used according to the invention can be mixed with other proteins in a proportion of up to 30% by mass with respect to the milk protein. For this, other albumins, such as ovalbumin and vegetable proteins, in particular lupine protein, soy protein or wheat proteins, in particular gluten can be used.

[0016] The plasticizer is preferably water which is used in a proportion comprised between 20 and 80% with regard to the weight of the protein, preferably in a proportion comprised between approximately 40 and 50% by mass of the protein content. Instead of water or mixed with this one, other plasticizers, in particular alcohols, poly alcohols, gum Arabic, carbohydrates in aqueous solution and in particular aqueous polysaccharide solutions can be used. The moisture content of the protein fraction has to be considered, if necessary.
In detail, the following plasticizers and associated proportions are especially preferred:

Alcohols and poly alcohols are used in proportions of up to approximately 10% by mass with regard to the protein, especially preferred is glycerol (glycerine). Other polyols, for example ethylene glycol can be alternatively used. Carbohydrates and polysaccharides are respectively used in a proportion preferably comprised between 0.4 and 2% by mass, respectively in 70% aqueous solution. Starches of different origin are preferred, such as carrageenan, cellulose, in particular carboxycellulose and chitosan.

The addition of other agents is not excluded. Additives and auxiliary agents, such as lipophile additions, glossing agents and crosslinking agents can be especially provided. The additives and auxiliary agents shall altogether not exceed a proportion of maximum approximately 30% by mass with regard to the protein. Vegetable oils can be chosen as lipophile additions which slightly hydrophobize the fiber already during the plasticizing operation. Furthermore, waxes can be used which additionally give the fiber stability. Preferred waxes are carnauba wax, beeswax, candelilla wax and other naturally obtained waxes.

Calcium salts, for example calcium chloride, dialdehyde starch and glucose-6-lactone are preferred as crosslinking agents.

In a highly preferred embodiment the plasticizing is realized by means of an extruder, wherein all the selected substances are previously mixed and then fed into the extruder, or only some substances or only the protein are charged at the beginning and other substances are added in the course of the extrusion, i.e. at feeding spots along the screw.

In a highly preferred embodiment it is provided that the protein is fed into the extruder as dry powder via a hopper at the entry of the extruder, whereas the plasticizer and in particular water is added in a following extrusion step, into the plasticizing zone. Furthermore, it is preferred that all dry starting substances are previously mixed and fed into the extruder at the beginning, whereas all liquid components are admixed downstream. At the exit of the extruder, the extruded material is pressed through a jet and thus formed to a fiber.

If the protein is used as flocculated raw mixture, the procedure preferably provides that a dewatering can take place along the extruder or the other processing device.

Due to the plastification, the operation corresponds to a melt extrusion. In this theroplastic extrusion, the materials are transferred into a plastic state through heating and are deformed in this way. Herein, the temperature exceeds the glass transition temperature of the protein, such that this one changes from the amorphous to the rubber-like plastic state. If the fulling and kneading is very strong, heat will already be generated by the mechanical stress such that it can happen that no heat has to be supplied from outside. Then, the extrusion already takes place at room temperature. However, usually very specific temperatures that allow an optimum plastification have to be set in the different extruder zones. Preferably it is extruded within the extruder between 30 and 95 °C, more preferably between 50 and 90 °C, and most preferably between about 60 and 80 °C.

Furthermore it is preferred that the formed fiber will be wound up after getting out of the jet and will be dried before and/or after this step.

After the formed fiber has left the jet, it can be cut immediately—for example be chopped into short fibers—or be further processed to staple fibers.

Immediately after the formed fiber has left the jet or in at least one subsequent processing step, the fiber can alternatively be further processed to a plied yarn, can be in particular twisted, be loosely coiled up to a cotton wool or be further processed to a fleece.

In an improvement of the invention, the fiber can furthermore pass through a bath before being wound up, although this procedure is not much preferred and usually not required. Alternatively the fiber can be subjected to a spraying treatment after having left the jet. Herein, smoothing agents, waxes, lipophiles or crosslinking agents can be for example applied to the surface of the fiber. In the case of crosslinking agents, the above mentioned ones are preferred, i.e. generally different salt solutions, preferably calcium chloride solution, dialdehyde starch solution, glucose-6-lactone solution or aqueous lactic acid.

The obtained fibers can be used for all imaginable purposes. They are usable like common textile fibers and can thus be processed to all kinds of textiles, such as fabrics, woven fabrics, knitted fabrics, crocheted textile fabrics, yarns, ropes, fleeces, felts etc. Also cotton wools, loose fiber insulating materials, filters and membranes can be obtained from the fibers according to the invention. The application fields of the milk fibers therefore comprise, inter alia, the textile technique, building insulation and building materials, hygiene products and, due to inherent antibacterial properties, medical products, such as swabs, filters and membranes.

Part of this invention is therefore also a milk protein fiber product that contains fibers which contain a thermally-mechanically plasticized milk protein and have in particular been obtained by means of a method according to the invention as described above.

If the fibers are loosely coiled up, it is for example possible to produce cotton wools or fleeces which can for example be used as filling and padding material.

It is especially preferred that the fibers are twisted to yarns. Herein, it is both possible to twist several milk protein fibers which have been produced by means of the method according to this invention with each other and to twist the milk protein fibers with other natural or synthetic fibers in a combination. Elastane (spandex), viscose, silk or wool can be for example used as other fibers which can also be spun and/or twisted in mixtures to plied yarns.

Single fibers are obtained by a discontinuous procedure. The fibers can also be cut to short fibers or staple fibers.

Fabrics can on the other hand be produced from the obtained fibers, filaments or yarns. Woven and knitted fabrics of all kinds therefore also represent milk protein fiber products according to this invention.

Advantages of the Invention

The advantages obtained by the invention are in particular based upon the fact that during the production of milk protein fibers the extrusion process allows excluding substances which present a risk to health and are harmful to the environment from the process and from the fiber itself. Furthermore, considerable resources of energy, water, time and manpower can be saved, which also improves the environmental protection and increases the economical efficiency. The especially advantageous properties of the fibers which are highly suitable as textile fibers are based upon the solidifying structural changes (textile structure) which occur during the plasticizing. More detailed knowledge about the mechanistic aspects has not been gained so far.
EXAMPLES

In the following, the invention will be described in detail by means of an exemplary embodiment. The exemplary embodiment only serves to illustrating purposes and shall not limit the invention. On the base of this exemplary embodiment and his know-how, the man skilled in the art can find other possible embodiments by varying the parameters.

Example 1

The casein powder is supplied via a vibrating conveyor. The water is added in a proportion of 1:2 (water:casein) by means of a peristaltic pump. The fiber strength is defined by the jet strength. The fiber can for example have a strength of 20 dtex. The fibers are wound up by means of a winding machine and dried at room temperature.

The course of the extrusion becomes additionally apparent in FIG. 1.

The extruder 1 is filled with the casein powder via a hopper 2. The casein powder is heated up in the extruder. The addition of water as plasticizer is realized by means of a water pump. The final product is pressed through a jet 4. The fiber strand is wound up by means of a suitable winding technology and dried on the winder 5 at room temperature.

What is claimed is:

1. A method for producing milk protein fibers, wherein at least one protein obtained from milk is plasticized together with a plasticizer at temperatures comprised between room temperature and 140°C under mechanical stress and is spun through a jet, characterized in that the plasticizer is selected from the group: aqueous polysaccharide solution, alcohol, polyalcohol or mixtures of these substances.
2. A method according to claim 1, characterized in that the protein obtained from milk is produced in situ by precipitation from milk.
3. A method according to claim 1, characterized in that the protein obtained from milk is used in form of a previously separately obtained protein.
4. A method according to claim 1, characterized in that the protein obtained from milk is casein.
5. A method according to claim 1, characterized in that the protein obtained from milk is lactalbumin.
6. A method according to claim 1, characterized in that the plasticizing takes place at temperatures up to maximum 80°C.
7. A method according to claim 1, characterized in that other additives and auxiliary agents are added to the starting substance to be plasticized.
8. A method according to claim 1, characterized in that the plasticizing is carried out by means of an extruder and the fiber is pressed through a jet at the exit of the extruder and formed thereby.
9. A method according to claim 1, characterized in that the formed fiber is wound up.
10. A method according to claim 1, characterized in that the formed fiber is dried.
11. A method according to claim 1, characterized in that the formed fiber is cut immediately after it has left the jet.
12. A method according to claim 1, characterized in that the formed fiber passes through a bath before being wound up.
13. A method according to claim 1, characterized in that the formed fiber is subjected to a spraying treatment before being wound up.
14. A milk protein fiber product which contains fibers that have been produced according to the method of claim 1.

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