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(54) **METHOD FOR PRODUCING HEMP FIBER FOR SPINNING, AND HEMP FIBER FOR SPINNING**

(57) A production method of hemp fiber for spinning, the method including an immersion treatment process of immersing raw hemp fiber in a treatment liquid including water and at least one type of enzyme selected from the group consisting of protease enzymes and starch hydro-

lyzing enzymes for an immersion time of from 30 minutes to 60 minutes under a condition of a temperature of from 60°C to 100°C, a water-washing process of washing the immersion treated hemp fiber with water, and a drying process of drying the water-washed hemp fiber.

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Description

Technical Field

[0001] The present invention relates to a production method of hemp fiber for spinning, and hemp fiber for spinning.

Background Art

[0002] As warming phenomena have recently become a problem for Earth's environment, there is demand for materials having excellent cooling sensation in human clothing. The popularity of hemp materials, these being natural materials that are light and dry to the touch, is increasing in the textiles market, and demand for hemp fiber cloth is growing.

[0003] Cotton fiber, which, like hemp, is a natural cellulose fiber, is derived from the seeds of a plant known as cotton, is a fiber that is soft itself, and has excellent spinnability and workability. In hemp, however, the raw material part employed in cloth manufacture is the leaf or stem of the plant. Since the leaf and stem are made of cellulose, and components such as lignin are present between the fibers, the fiber material has high strength but is also hard, with smooth fiber surfaces, making the material difficult to work, and cloth obtained by working the material sometimes feels rough, worsening the feel.

[0004] Technology for improving the feeling of cellulose fibers such as hemp fibers has been proposed, such as a method of treating the surface of cellulose-based fiber woven fabrics with a cellulolytic enzyme, and then with a strong alkaline aqueous solution (for example, see Japanese Patent Application Laid-Open (JP-A) No. H05-247852).

[0005] That method is technology to solve the problem concerned with improving the feel of woven fabric surfaces made from cellulose fibers such as hemp, and consideration has not been given to application to working of raw fiber materials, such as threads for spinning.

[0006] Hemp fibers have high strength, but are stiff. Since hemp fibers have a smooth surface, there are therefore problems that when attempting to perform work in which hemp fibers are spun and the hemp thread obtained is weaved or knitted to make a woven product or a knitted product, hemp fibers are not easily caught by spinning devices generally employed for producing twisted threads, yield is low when the fiber is spun, fiber fall-off and thread snapping are liable to occur, and productivity is low. Moreover, since hemp fiber is stiff, twisted threads having a fine diameter, twisted threads having a uniform thread thickness, and the like are difficult to obtain, and this also causes a decrease in productivity in the production of fabrics and knitted products that employ these hemp threads.

[0007] Historically, methods of making raw fiber materials by splitting leaves and stems of plants such as hemp have been performed since ancient times. One such

method performed since ancient times is a method employing a physical procedure in which hemp fibers are finely shredded, the fibers are beaten with a fulling block and carded in order to remove substances such as lignin between cellulose fiber cells and soften the material.

[0008] Likewise in recent times, methods such as compressing hemp fibers between rollers before spinning the hemp fiber are used, but the current situation is that sufficient yields are not achieved when spinning. Moreover, although it is known that treating cellulose fibers with strong alkali or strong acid enhances softness, the strength of the fibers is notably reduced making this impractical.

[0009] Accordingly, many hemp fiber products that are currently distributed have a characteristic feeling caused by the unevenness of threads made from hemp fiber, and there is a desire to provide highly versatile, twisted hemp threads or hemp cloth that have softness similar to cotton.

[0010] As a method of improving hemp fibers, a method has been proposed for removing pectin, lignin, and the like present between hemp fiber cellulose by treating the hemp fibers with a treatment liquid including a cellulolytic enzyme, and it has been described that a hemp fiber having low skin irritancy and excellent spinnability can be obtained by this treatment (for example, see JP-A No. H01-139874).

SUMMARY OF INVENTION

Technical Problem

[0011] However, the working technology described by JP-A No. H05-247852 is technology related to surface working on cloth obtained by weaving or knitting fibers, and no consideration is given to fiber treatments suitable for spinning.

[0012] JP-A No. H01-139874 describes softness being held by removing lignin and the like in plant fibers such as hemp and cotton using an cellulolytic enzyme, and also describes an effect of suppressing skin irritancy of hemp fibers by rounding off and removing the edges of tips by dissolving the tips of the hemp fibers. However, in investigations by the present inventors, although it was recognized that the use of a cellulolytic enzyme has a somewhat effect on cotton fibers, it was confirmed that this was not enough for the surface of hemp fibers to be worked into a state appropriate for spinning employing a general spinning device.

[0013] Although the feeling and the like of the surface of the cloth is improved in such conventional treatment technology for hemp fiber, the physical properties of the fibers to be a cloth cannot be adjusted into a state suitable for spinning employing a spinning device, and the current situation is that a production method for hemp fiber that enables spinning with high industrial productivity has not yet been obtained.

[0014] One embodiment of the present invention is concerned with, by simple treatment, providing a produc-

tion method of hemp fiber for spinning that is soft and that can be spun with high productivity. Another embodiment of the present invention is concerned with providing hemp fiber having excellent spinnability.

Solution to Problem

[0015] A solution to the problem includes the following aspects.

<1> A method of producing hemp fiber for spinning, comprising: immersing raw hemp fiber in a treatment liquid containing water and at least one enzyme selected from the group consisting of proteases and starch hydrolyzing enzymes, for from 30 minutes to 60 minutes at a temperature of from 60°C to 100°C; washing the immersion treated hemp fiber with water; and drying the washed hemp fiber.

<2> The method of producing hemp fiber for spinning of <1>, wherein the treatment liquid contains an alkaline agent.

<3> The method of producing hemp fiber for spinning of <1> or <2>, wherein the treatment liquid has a pH of from 9 to 13.

<4> The method of producing hemp fiber for spinning of any one of <1> to <3>, further comprising a post-treatment, after the washing, wherein the post-treatment comprises immersing the washed hemp fiber in a post-treatment liquid containing water and at least one compound selected from the group consisting of sodium nitrobenzenesulfonate and sodium cyanurate, for from 20 minutes to 50 minutes at a temperature of from 60°C to 100°C.

<5> A hemp fiber for spinning that is obtained by the method of producing hemp fiber of any one of <1> to <4>, having a narrower fiber diameter than that of raw hemp fiber, being twisted, and having fine naps on a fiber surface.

Advantageous Effects of Invention

[0016] One embodiment of the present invention can, by a simple treatment, provide a production method of hemp fiber for spinning that is soft and that can be spun with high productivity. Another embodiment can provide hemp fiber having excellent spinnability.

DESCRIPTION OF EMBODIMENTS

[0017] Detailed explanation follows regarding the present invention.

Production Method of Hemp Fiber for Spinning

[0018] A production method of hemp fiber for spinning, which is one embodiment of the present invention, includes: immersing raw hemp fiber in a treatment liquid containing water and at least one enzyme selected from

the group consisting of proteases and starch hydrolyzing enzymes (also referred to as an enzyme treatment liquid hereafter), and heating for from 30 minutes to 60 minutes at a temperature of from 60°C to 100°C (also referred to as an enzyme treatment process hereafter), washing the immersion treated hemp fiber with water (also referred to as a water-washing process hereafter), and drying the water-washed hemp fiber (also referred to as a drying process hereafter).

[0019] In the present specification, "raw hemp fiber" refers to hemp fiber prior to carrying out any of the treatments in the production method of hemp fiber for spinning, this being the raw form of hemp fiber for spinning.

[0020] The mechanism of the present embodiment is not clear, but is thought to be as follows.

[0021] In the production method of the present embodiment, the enzyme treatment liquid including a specific enzyme capable of breaking down protein, starch, or the like is heated, and immersion treating hemp fiber in the heated enzyme treatment liquid causes the hemp fiber to swell and become easily permeable to moisture. As the enzyme treatment liquid causes the fiber to swell, moisture together with enzymes enters between fibers and stay there, making the fiber in a state in which lignin and the like present between cellulose swells and is easily removed, and make the fiber soft. Lignin and the like present between cellulose is removed, by water-washing and drying the enzyme-treated fiber, and voids between cellulose are fixed. Thus, on the surface of the hemp fiber, fine naps are generated at places where the lignin and the like between cellulose has been removed. Moreover, fine hollow portions are formed at a central portion of the hemp fiber, fibrillation proceeds, and twisting occurs in the fibers with the washing and drying after the immersion treatment in the enzyme treatment liquid. Thus, it is hypothesized that hemp fiber is produced that has naps on the surface, that has softness and twisting, and that is easily caught by a spinning device.

[0022] The enzyme itself employed in the present embodiment is an enzyme that does not dissolve cellulose, and there is therefore no concern that the fiber strength may be lowered by employing the enzyme.

[0023] Note that the present embodiment is not limited in any way by this hypothesized mechanism.

[0024] Explanation follows regarding the production method of hemp fiber for spinning of the present embodiment, in order of the processes.

Immersion Treatment Process

[0025] In the production method of hemp fiber for spinning of the present embodiment, first, raw hemp fiber is immersed in treatment liquid that contains water and at least one enzyme selected from the group consisting of proteases and starch hydrolyzing enzymes to be treated.

Hemp Fiber

[0026] Although hemp fiber is often used to refer to ramie and flax, hemp fiber is not limited to hemp fibers of this narrow meaning in the present specification.

[0027] The raw hemp fiber applicable to the production method of hemp fiber for spinning of the present embodiment may be any hemp fiber. Hemp fiber in the present specification is, for example, used with a meaning that encompasses any hemp fiber derived from the hemp plants listed below.

[0028] Specific examples include cannabis (*Cannabis sativa* (Moraceae)), also known as hemp, flax (*Linum usitatissimum* (Linaceae)), ramie (*Boehmeria nivea* var. *nipponnivea* (Urticaceae)), also known as "choma" or "karamushi" in Japanese, kenaf (*Hibiscus cannabinus* (Malvaceae)), also known as "youma" in Japanese, jute (*Corchorus capsularis* (Tiliaceae)), Nalta jute (*Corchorus olitorius* (Tiliaceae)), Manila hemp (*Musa textilis* (Musaceae)), ambari of Malvaceae, gumbo hemp, Bombay hemp, sisal hemp (*Agave sisalana* (Agavoideae)), cannabis, lesser New Zealand flax, New Zealand hemp (*Phormium tenax* (Agavoideae)), China grass, and jute (*Corchorus olitorius* (Tiliaceae)), also known as "shimat-sunaso" in Japanese.

[0029] Moreover, jute, which is a hemp fiber obtained from *Corchorus capsularis* or *Corchorus olitorius*, is also encompassed in hemp fiber in the present specification.

[0030] Of the hemp fibers described above, the production method of the present embodiment is preferably applied to hemp, ramie, flax, or the like from the viewpoints of productivity in industrial scale and easiness to obtain the raw material.

[0031] The production method of hemp fiber for spinning of the present embodiment is also effective on fibers that are rigid cellulose fibers obtained from the leaves of *Cyperus monophyllus* Vahl, *Musa basjoo*, or banana, the leaves and stalks of *Alpinia zerumbet*, and the bark, stems, leaves, and the like of *Cyperus papyrus*, *Schefflera arboricola*, *Broussonetia kazinoki* × *B. papyrifera*, *Edgeworthia chrysantha*, *Diplomorpha sikokiana*, *Salix* species, bamboos, and *Nelumbo nucifera*. However, the production method of hemp fiber for spinning of the present embodiment has a notable advantageous effect of improving productivity when employed with hemp fiber.

[0032] There are no particular limitations to the method of obtaining hemp fiber from plants, and a known method may be employed. Ordinarily, a plant (hemp) as the raw material is immersed in an aqueous solution that contains water and a chemical such as an acid, and fiber strings are taken out, water-washed, and dried to obtain hemp fiber.

Pre-treatment of Hemp Fiber

[0033] In the production method of the present embodiment, the raw hemp fiber may first cut into lengths of from approximately 2 cm to approximately 20 cm to fa-

cilitate working. The length may be appropriately determined according to the characteristics of the hemp fiber employed as the raw material, and cutting to a length of from approximately 2 cm to approximately 15 cm is preferable.

[0034] According to the production method of the present embodiment, although the raw hemp fibers are often cut to from 3.5 cm to 5.5 cm conventionally, for example, raw hemp fibers cut to from 7 cm to 13 cm are also suitable for use since softness and workability can be improved even when the raw hemp fibers employed are long fibers. Generally, the longer the fiber length, the more effectively skin irritation caused by the hemp fiber is suppressed, and the more applicability to spinning devices is improved.

[0035] The length of the raw hemp fiber is, for example, preferably from approximately 8 cm to approximately 12 cm when hemp is employed, is preferably from approximately 3 cm to approximately 6 cm when ramie is employed, and is preferably from approximately 2 cm to approximately 5 cm when flax is employed. However, there are no limitations thereto.

[0036] Immersing cut raw hemp fiber in water and then immersing the cut raw hemp fiber in the enzyme treatment liquid that contains the enzyme is preferable.

[0037] The raw hemp fiber may be pre-washed prior to immersion in the treatment liquid that contains the enzyme, and may be immersed in an aqueous solution that includes an alkaline agent (also referred to as an alkaline-agent-containing aqueous solution hereafter) such as an aqueous sodium hydroxide solution for removing dirt from the raw hemp fiber, and then may be water-wash treated. The alkaline-agent-containing aqueous solution employed in the pre-treatment of the raw hemp fiber preferably contains the alkaline agent at a concentration of from 3% by mass to 10% by mass for the purpose of removing dirt adhered to the fiber. Immersion of the raw hemp fiber in the alkaline-agent-containing aqueous solution for the purpose of washing may be performed without heating the alkaline-agent-containing aqueous solution, at a temperature of from approximately 10°C to approximately 25°C, this being the temperature of the water employed to prepare the aqueous solution, or may be performed by heating the alkaline-agent-containing aqueous solution to a temperature of approximately 80°C. The immersion time is preferably from approximately 40 minutes to approximately 120 minutes in cases in which the aqueous solution is not heated, and is preferably from approximately 20 minutes to approximately 40 minutes in cases in which the aqueous solution is heated.

[0038] Explanation follows regarding components included in the enzyme treatment liquid employed in the immersion treatment process.

At Least One Enzyme Selected from the Group Consisting of Proteases and Starch Hydrolyzing Enzymes

[0039] The following proteases and starch hydrolyzing enzymes are preferable examples of the enzyme employed to prepare the enzyme treatment liquid employed in the immersion treatment process.

[A] Protease

[0040] Any protease classified as a cysteine protease may be employed as the protease in the present invention.

[0041] Specific examples of the protease include bromelain contained in pineapples and the like (also referred to as pineapple enzyme), actinidain contained in kiwi fruit, ficain contained in figs, and papain contained in papayas. Of these, bromelain and papain are preferable from the viewpoint of effectiveness.

[0042] The protease can be obtained as a reagent or as papaya enzyme powder or the like employed in cosmetics, food products, and the like. Moreover, the protease can be obtained by fermenting fruit or the like that includes the enzyme, or by extracting the enzyme from the raw juice of the fruit.

[0043] Examples of commercial products include BROMELAIN 1000GPU (trade name, Jarrow Formulas) or BROMELAIN powder (trade name, manufactured by Life Extension quality Supplements and Vitamins, Inc). The enzymes of these commercial products may be tablets or powdered forms that can be employed in the enzyme treatment liquid by dissolving in a solvent such as water.

[B] Starch Hydrolyzing Enzyme

[0044] Examples of the starch hydrolyzing enzyme include amylase or diastase.

[0045] The starch hydrolyzing enzyme can be obtained as a reagent.

Solvent

[0046] Water is preferably employed as the solvent of the enzyme treatment liquid. The solvent may employ water alone. Water serving as the solvent may further include citric acid or the like at from 2% by mass to 10% by mass with respect to all of the solvent, for the purpose of softening the fiber.

Additives

[0047] Other than the solvent that contains the enzyme and water, various additives may be included in the enzyme treatment liquid according to the object, within ranges that do not hinder the advantageous effects of the present embodiment.

[0048] Examples of additives include alkaline agents.

An alkaline agent is preferably contained in the enzyme treatment liquid from the viewpoint of promoting permeation of the enzyme into the hemp fiber.

[0049] Examples of the alkaline agent include sodium hydroxide, potassium hydroxide, sodium sulfate, and caustic lime. The alkaline agent may be added to the enzyme treatment liquid in the form of an aqueous solution.

[0050] Including an alkaline agent in the enzyme treatment liquid to set the pH to from 9 to 13, or more preferably from 11 to 13, improves permeability of the enzyme toward the raw hemp fiber, and also further improves softness of the obtained hemp fiber and promotes generation of naps on the surface, since the solubility of lignin and the like is improved by the alkaline agent.

[0051] Moreover, combined employment of the alkaline agent has the merit that a well-suited hemp fiber for spinning can be obtained even if the immersion time in the enzyme treatment liquid is short.

Preparation of Enzyme Treatment Liquid

[0052] The enzyme treatment liquid is prepared by placing from 5 equivalents to 20 equivalents by mass of solvent with respect to the raw hemp fiber in a container, adding the enzyme selected from proteases or starch hydrolyzing enzymes at a liquid temperature of from 60°C to 100°C, and agitating sufficiently. The timing at which additives employed if desired are added to the enzyme treatment liquid may be freely selected, and may be prior to addition of the enzyme, may be after addition of the enzyme, or may be at the same time as the enzyme.

[0053] One type, two types, or more types of the enzymes described above may be contained in the enzyme treatment liquid.

[0054] The total content of the enzyme in the enzyme treatment liquid is preferably from 3 parts by mass to 10 parts by mass with respect to 100 parts by mass of the raw hemp fiber, and is more preferably from 3 parts by mass to 5 parts by mass with respect to 100 parts by mass of the fiber.

Immersion Treatment

[0055] Raw hemp fiber on which pre-treatments such as washing have been performed if desired is immersed in the prepared enzyme treatment liquid.

[0056] The cut raw hemp fiber is immersed for from 30 minutes to 60 minutes with the liquid temperature of the enzyme treatment liquid kept under a condition of a temperature of from 60°C to 100°C.

[0057] From the viewpoint of effectiveness, the liquid temperature of the enzyme treatment liquid during immersion is more preferably from 70°C to 90°C. The immersion time is more preferably from 35 minutes to 60 minutes.

[0058] The hemp fiber is preferably immersed while agitating the enzyme treatment liquid so that the hemp

fiber and the enzyme make sufficient contact and permeation of the enzyme treatment liquid between fibers is promoted during immersion.

[0059] From such viewpoints, the enzyme immersion treatment of the hemp fiber is preferably performed using a container or device equipped with an agitation device. From the viewpoint of being able to agitate while maintaining the temperature conditions during immersion, a washer machine, a paddle machine, an Obermaier machine, or the like, which are known dyeing machines, is also preferably employed in the immersion treatment.

[0060] Moreover, the permeation of the treatment liquid into the hemp fiber can also be promoted by supplying a gas to bubble through the enzyme treatment liquid.

[0061] Although immersion treatment performed using a container or device equipped with temperature regulating functionality is also a preferable mode, there is no particular limitation thereto. The temperature regulation of the enzyme treatment liquid can be performed by a known method such as heating from outside the container or heating by an immersion heater or the like.

Water-Washing Process

[0062] The hemp fiber that has been immersed in the enzyme treatment liquid is taken out of the container containing the enzyme treatment liquid, and the water-washing process is applied.

[0063] Water-washing liquid employed in the water-washing process may be water-washing liquid that contains water alone, or may be water-washing liquid containing a known additive in addition to water if desired.

[0064] The water employed in the water-washing process may be tap water.

[0065] In the water-washing process, the hemp fiber is sufficiently washed to remove the treatment liquid, alkaline agent, and the like remaining on the fiber surface and in voids within the fibers.

[0066] The water-washing liquid employed in the water-washing process may include a surfactant. Including a surfactant in the water-washing liquid further improves the washing effect of removing components remaining between fibers. After having been washed by the water-washing liquid that contains the surfactant, water-washing is preferably performed using a water-washing liquid that does not include a surfactant to remove the surfactant from the fiber.

[0067] The water-washing may be performed using flowing water, or may be performed by placing in a container containing water and agitating. In cases in which water-washing is performed in a container, the water is preferably changed at least one or two times.

Post-treatment Process

[0068] After the water-washing process, a drying process, described later, is applied to the hemp fiber from which the enzyme treatment liquid has been removed.

[0069] A post-treatment process is preferably performed prior to drying. Performing the post-treatment process fixes voids in the hemp fiber and the napping state formed by swelling due to the enzyme, enabling hemp fiber that has physical properties suited to spinning to be obtained.

[0070] The post-treatment is performed by immersing the water-washed hemp fiber in a post-treatment liquid that contains water and at least one compound selected from the group consisting of sodium nitrobenzenesulfonate and sodium cyanurate (also referred to as a post-treatment agent hereafter), and holding the hemp fiber immersed for from 20 minutes to 50 minutes while maintaining the liquid temperature at from 60°C to 100°C.

[0071] Sodium nitrobenzene sulfonate and sodium cyanurate are known dye stabilizing agents and can be obtained as commercial products.

[0072] One type of post-treatment agent alone, or two types of post-treatment agent, may be included in the post-treatment liquid.

[0073] The total content of the post-treatment agent in the post-treatment liquid is preferably from 2% by mass to 10% by mass and is more preferably from 2% by mass to 4% by mass.

[0074] The mechanism of the post-treatment process is not clear, but is hypothesized to be as follows.

[0075] It is thought that by applying at least one type of compound selected from sodium nitrobenzenesulfonate or sodium cyanurate to the hemp fiber that has been enzyme treated via the immersion treatment process, the acidic group included in the sodium nitrobenzenesulfonate or sodium cyanurate creates a hydrogen bonding interaction with moisture contained in the hemp fiber, and bonds to voids within the hemp fiber formed by swelling and to the naps on the hemp fiber surface, and effectively holds that form.

[0076] The hemp fiber that has been through the post-treatment process is water-washed to remove the post-treatment liquid, and the drying process is applied.

Drying Process

[0077] The hemp fiber that has been through the immersion treatment process in the enzyme treatment liquid, the water-washing process, and the post-treatment process performed if desired, is dried to obtain hemp fiber for spinning.

[0078] Drying of the fiber can be performed using ordinary methods. The device employed for drying may be, for example, a known band-type drying machine that employs a net or belt, a tumble drying machine for fibers, a non-contact-type dome-style drying machine that employs infrared, or a drying machine that dries using electromagnetic waves such as a microwave oven.

[0079] The drying temperature is preferably an atmosphere temperature of from approximately 90°C to approximately 180°C. The temperature of the hemp fibers is heated to approximately 100°C in cases of drying by di-

rect heating using electromagnetic waves.

[0080] The hemp fibers need not be dried to a fully dry state in the drying process; drying to a dried state at which preservation or employment in a spinning device is not hindered is sufficient.

[0081] In the hemp fiber obtained by the production method of hemp fiber for spinning of the present embodiment, twisting occurs caused by fine voids present between fibers, the hemp fibers are soft, and there are abundant fine naps on the surface.

[0082] Thus, in cases in which the hemp fiber is applied to a general purpose spinning device, fall-off of the fiber is suppressed, and twisted hemp fiber threads can be obtained with high productivity.

[0083] The obtained hemp fiber for spinning is carded to form a sliver using an ordinary method, and then supplied to a spinning device.

Hemp Fiber for Spinning

[0084] The hemp fiber for spinning obtained by the production method of hemp fiber for spinning of the present embodiment described above has a narrower fiber diameter than raw hemp fiber, has twisting, and has fine naps on the fiber surface.

[0085] Namely, the hemp fiber for spinning of the present embodiment is in a form in which fine fibers that were previously fused are separated by removing lignin and the like included in the raw hemp fiber, and fiber having a narrower fiber diameter than raw hemp fiber is observed. Moreover, twisting arises due to fine voids present between the fibers, imparting stretchiness, and there is softness. Moreover, since the surface has abundant fine naps, fall-off of the fiber is suppressed, and twisted threads of uniform thickness are formed with good productivity when the fiber is applied to a standard spinning device.

[0086] The form, external appearance, and cross-section of the hemp fiber for spinning can be observed by an optical microscope. The magnification ratio when observing using an optical microscope is preferably from 300× to 1500×, but the magnification ratio is not particularly limited.

[0087] For example, in cases in which the entire hemp fiber for spinning is observed, a magnification ratio of from approximately 300× to approximately 400× is well-suited for this observation, and when the napping state of the surface or a portion such as the cross-section is observed, a magnification ratio of from approximately 1,000× to approximately 1,500× is well-suited for this observation.

[0088] Capture of optical micrographs employed in observation of the hemp fiber for spinning of the present embodiment was contracted to Tokyo Metropolitan Industrial Technology Research Institute, Sumida Branch, Human Life Technology Development Sector.

[0089] Uniform twisted threads with a finer yarn count than conventional hemp fiber can be easily obtained

since the hemp fiber for spinning of the present embodiment has softness that is not seen in conventional hemp fibers.

[0090] Thus, application can be made to various thin, soft final products such as clothing, underwear, and scarves that are conventionally difficult to form using hemp fiber.

Examples

[0091] More specific explanation follows regarding examples of the present embodiment, but the present embodiment is not in any way restricted to these examples.

Example 1

[0092] Hemp serving as raw hemp fiber was cut into lengths of 11 cm. 100 g of the cut hemp fiber was prepared.

[0093] 2 kg of water (2 L) was placed in a container made from stainless steel, 5 g of pineapple enzyme (powder obtained by crushing tablets of BROMELAIN 1000GPU (trade name), manufactured by Jarrow Formulas) was added, and well agitated to prepare enzyme treatment liquid A.

[0094] The enzyme treatment liquid A was heated to 80°C, the prepared 100 g of hemp fiber was immersed in the enzyme treatment liquid A, and was held immersed for 30 minutes while maintaining a liquid temperature of 80°C.

[0095] Afterwards, the hemp fiber was taken from the enzyme treatment liquid, water-washed with flowing water, and gently wrung, and then the hemp fiber was placed in a 20 d nylon mesh bag, and dried for 45 minutes using a tumble drying machine to obtain a hemp fiber for spinning of Example 1.

[0096] The hemp fiber for spinning was observed by eye and was sensory evaluated with respect to tactile sensation. It was confirmed that the obtained hemp fiber for spinning of Example 1 was bulky and soft, and that the feel was improved compared to the hemp fiber prior to working.

[0097] The obtained hemp fiber for spinning of Example 1 was observed using an optical microscope (magnification ratio: 400×). Naps on the surface due to split of threads and/or broken of threads was observed on a side face of the fiber, and the occurrence of a curve in which the fibers were somewhat twisted was confirmed. Moreover, in an observation of the cross-section of the threads, it was confirmed that hollow portions were formed in the fiber, and that peripheral edges were more swollen than prior to working.

Example 2

[0098] Hemp serving as hemp fiber was cut into lengths of 11 cm. 100 g of the cut hemp fiber was prepared.

[0099] 2 kg of water (2 L) was placed in a container made from stainless steel, 5 g of the pineapple enzyme as that employed in Example 1 and 4 g of an aqueous solution of 25% by mass sodium hydroxide were added, and enzyme treatment liquid B was prepared by agitating sufficiently.

[0100] Hemp fiber for spinning of Example 2 was obtained similarly to in Example 1 except for employing the enzyme treatment liquid B in which sodium hydroxide had been added.

[0101] The hemp fiber for spinning was observed by eye and was sensory evaluated with respect to tactile sensation. It was confirmed that the obtained hemp fiber for spinning of Example 2 was bulky and soft and that the feel was improved compared to the hemp fiber prior to working.

[0102] The obtained hemp fiber was observed using an optical microscope (magnification ratio: 400×). Naps on the surface due to split of threads and/or broken of threads was observed on a side face of the fiber, and the occurrence of a curve in which the threads were somewhat twisted was confirmed. Moreover, The cross-section of the threads was observed. It was confirmed that hollow portions were formed in the fiber, and that peripheral edges were more swollen than prior to working, and no great differences from the hemp fiber for spinning of Example 1 were seen.

Example 3

[0103] Hemp serving as hemp fiber was cut into lengths of 11 cm. 100 g of the cut hemp fiber was prepared.

[0104] 2 kg of water (2 L) was placed in a container made from stainless steel, 5 g of the pineapple enzyme that was employed in Example 1 and 3 g of citric acid were added, and well agitated to prepare enzyme treatment liquid C.

[0105] The prepared 100 g of hemp was immersed in the enzyme treatment liquid C, and the enzyme treatment liquid C was heated to 80°C over a period of 10 minutes while being agitated using a 2 cm diameter stainless steel rod. The liquid temperature was maintained at 80°C and held for 30 minutes while agitation continued. When about 20 minutes had elapsed since the start of agitation, the hemp in the enzyme treatment liquid C had finely dispersed in a cotton-like form and had wrapped around the stainless steel agitating rod.

[0106] After 30 minutes of immersion and agitation, the hemp fiber was taken from the enzyme treatment liquid C, water-washed with flowing water, and gently wrung, and then the hemp fiber was placed in a 20 d nylon mesh bag, and dried for 45 minutes using a tumble drying machine to obtain a hemp fiber for spinning of Example 3.

[0107] The hemp fiber for spinning was observed by an optical microscope (magnification: 400×). Naps on the surface due to split of threads and/or broken of threads was observed on a side face of the fiber. More-

over, due to agitating, it was observed that more thoroughly split into a state of fiber with a fine cross-section than the hemp fiber for spinning obtained by Example 2, more abundant naps on the surface than in the hemp fiber for spinning obtained by Example 2.

Example 4

[0108] Sliver thread of cannabis was cut to lengths of 10.5 cm, and 15 g thereof was prepared.

[0109] 500 g of water was placed in a stainless steel container, and 2 g of papaya enzyme (papaya enzyme (trade name), manufactured by Life Extension quality Supplements and Vitamins. Ink) was added, and well mixed to prepare enzyme treatment liquid D.

[0110] 15 g of the prepared sliver threads of cannabis was immersed in the enzyme treatment liquid D, the enzyme treatment liquid D was heated to 80°C, and the sliver threads of cannabis was held immersed for 30 minutes while the liquid temperature was maintained at 80°C.

[0111] After immersion, the hemp fiber was taken from the enzyme treatment liquid D, water-washed with flowing water, gently wrung, and then placed in a 20 d nylon mesh bag and dried for 45 minutes using a tumble drying machine to obtain hemp fiber for spinning of Example 4.

[0112] The hemp fiber for spinning was observed by an optical microscope (magnification: 400×). Naps on the surface due to split of threads and/or broken of threads was observed on a side face of the fiber. Moreover, in an observation of the cross-section of the threads, it was confirmed that hollow portions were formed in the fiber, and that an aggregated state was formed from fibers having a smaller diameter than the raw hemp fiber prior to working, and peripheral edges of the aggregated fibers were swollen to a greater fiber diameter than the raw hemp fiber.

Example 5

[0113] Sliver threads of cannabis was cut to lengths of 10.5 cm, and 15 g thereof was prepared.

[0114] 500 g of water was placed in a stainless steel container, and 2 g of the papaya enzyme that was employed in Example 4 was added, and well mixed to prepare enzyme treatment liquid D as in Example 4.

[0115] The prepared 15 g of sliver threads of cannabis was immersed in the enzyme treatment liquid D, the enzyme treatment liquid D was heated to 80°C, and the sliver threads of cannabis was held immersed for 30 minutes while the liquid temperature was maintained at 80°C.

[0116] After immersion, the sliver threads of cannabis was lifted out from the stainless steel container, the enzyme treatment liquid in the stainless steel container was removed, the container was water-washed, and then 500 g of new water and 2 g of sodium nitrobenzenesulfonate were placed in the stainless steel container and well agitated to prepare a post-treatment liquid.

[0117] 10 g of the sliver threads of cannabis that was

lifted out from the enzyme treatment liquid D was placed in the post-treatment liquid, the liquid temperature was heated to 60°C, and the sliver threads of cannabis was immersed for 20 minutes while maintaining a temperature of 60°C to perform the post-treatment.

[0118] After the post-treatment process, the hemp fiber was water-washed with flowing water, gently wrung, and then placed in a 20 d nylon mesh bag, and dried for 45 minutes using a tumble drying machine to obtain hemp fiber for spinning of Example 5.

[0119] The obtained hemp fiber was observed by an optical microscope (magnification ratio: 400×). Naps on the surface due to split of threads and/or broken of threads were observed on a side face of the fiber. Moreover, in an observation of the cross-section of the threads, it was confirmed that hollow portions were formed in the fiber, and that an aggregated state was formed from fibers having a smaller diameter than the raw hemp fiber prior to working, and peripheral edges of the aggregated fibers were swollen to a greater fiber diameter than the raw hemp fiber.

[0120] When the hemp fiber obtained by Example 4 was compared with the hemp fiber obtained by Example 5, the cross-section diameter of the thread was greater in the hemp fiber of Example 5, and it is thought that the voids within the fiber were further enlarged by the post-treatment process.

[0121] The results showed that the swollen fibrous form given by the immersion treatment process using the enzyme treatment liquid is maintained in a more favorable state by performing the post-treatment process. This is thought to be because hydrogen bonding interactions to swelled portions of cellulose fibers are formed by the post-treatment liquid, and this yields a state in which the shape of voids and naps of the fiber is kept even after removing moisture and drying.

[0122] The entire content of the disclosure of Japanese Patent Application No. 2014-156920 filed on July 31, 2014 is incorporated by reference in the present specification.

[0123] All publications, patent applications and technical standards mentioned in the present specification are incorporated by reference in the present specification to the same extent as if each individual publication, patent application, or technical standard was specifically and individually indicated to be incorporated by reference.

Claims

1. A method of producing hemp fiber for spinning, comprising:

immersing raw hemp fiber in a treatment liquid containing water and at least one enzyme selected from the group consisting of proteases and starch hydrolyzing enzymes, for from 30 minutes to 60 minutes at a temperature of from

60°C to 100°C;

washing the immersion treated hemp fiber with water; and

drying the washed hemp fiber.

2. The method of producing hemp fiber for spinning of claim 1, wherein the treatment liquid contains an alkaline agent.
3. The method of producing hemp fiber for spinning of claim 1 or claim 2, wherein the treatment liquid has a pH of from 9 to 13.
4. The method of producing hemp fiber for spinning of any one of claim 1 to claim 3, further comprising a post-treatment, after the washing, wherein the post-treatment comprises immersing the washed hemp fiber in a post-treatment liquid containing water and at least one compound selected from the group consisting of sodium nitrobenzenesulfonate and sodium cyanurate, for from 20 minutes to 50 minutes at a temperature of from 60°C to 100°C.
5. A hemp fiber for spinning that is obtained by the method of producing hemp fiber of any one of claims 1 to claim 4, having a narrower fiber diameter than that of raw hemp fiber, being twisted, and having fine naps on a fiber surface.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/071869

A. CLASSIFICATION OF SUBJECT MATTER

D06M16/00(2006.01)i, D01C1/02(2006.01)i, D06M11/00(2006.01)i, D06M101/06(2006.01)n

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)

D06M16/00, D01C1/02, D06M11/00, D06M101/06

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 63-501515 A (Comite Economique Agricole de la Production du Chanvre, Akkawi, Jean Sony), 09 June 1988 (09.06.1988), claims; page 2, lower right column, lines 16 to 25; page 3, upper left column, lines 18 to 19; page 3, upper right column, lines 16 to 23; page 4, upper left column, lines 18 to 21 (Family: none)	1, 5
A	OSSOLA M. et al., Scouring of flax rove with the aid of enzymes, Enzyme and Microbial Technology, 2004.02, Vol.34, pp.177-186, ISSN 0141-0229 particularly, abstract, page 178, right column, line 1 to page 179, left column, line 4, fig. 1, 3, 4	1-5

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

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

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

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"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
13 October 2015 (13.10.15)Date of mailing of the international search report
20 October 2015 (20.10.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/071869

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RAMASWAMY G. N. et al., Uniformity and Softness of Kenaf Fibers for Textile Products, Textile Research Journal, 1995.12, Vol.65, No.12, pp.765-770, ISSN 0040-5175, particularly, abstract, page 765, left column, lines 13 to 21, page 766, left column, lines 24 to 45, right column, lines 16 to 28, table 1, page 768, right column, 5th line from the bottom to page 769, left column, line 21, fig. 1 to 3	1-5
A	JP 2010-540785 A (Jiangsu Redbud Textile Technology Co., Ltd.), 24 December 2010 (24.12.2010), claims; paragraph [0010]; examples 11 to 19, 21 & US 2010/0307703 A1 claims; paragraphs [0046] to [0047]; examples 11 to 19, 21 & WO 2009/049485 A1 & EP 2194172 A1 & CN 101135062 A & CN 101135064 A & CN 101130894 A & CA 2700896 A & KR 10-2010-0080773 A	1-5
A	JP 11-222770 A (Asahi Chemical Industry Co., Ltd.), 17 August 1999 (17.08.1999), paragraph [0006] (Family: none)	4

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H05247852 A [0004]
- JP H01139874 A [0012]
- JP 2014156920 A [0122]