Title: METHOD FOR PRODUCING WHITE SUGAR, LIGHT BROWN SUGAR AND DARK BROWN SUGAR USING DIRECT RECOVERY PROCESS

[Fig. 4]

Abstract: The present invention relates to a method for producing white sugar, brown white sugar and dark brown sugar, the method including: pressing and juicing sugar cane to extract sugar cane juice; adding lime to the juice and removing foreign matter and impurities from the juice; vacuum-concentrating the filtered juice in a first vacuum concentrator to produce a first crystal slurry containing sucrose; centrifuging the first crystal slurry in a first high-speed centrifuge into a first crystal and a first mother liquor and recovering the first crystal as dark brown sugar or transferring the first crystal to a second vacuum concentrator; vacuum-concentrating the transferred first crystal in the second vacuum concentrator to produce a second crystal slurry containing sucrose; centrifuging the second crystal slurry in a second high-speed centrifuge into a second crystal and a second mother liquor, transferring the second liquor to the pressing and juicing step, and drying the second crystal to produce brown white sugar, or transferring the second crystal to a third vacuum concentrator; vacuum-concentrating the transferred second crystal in the third vacuum concentrator to produce a third crystal slurry containing sucrose; and centrifuging the third crystal slurry in a third high-speed centrifuge into a third crystal and a third mother liquor, transferring the third mother liquor to the first vacuum concentrator, and drying the third crystal to produce white sugar.

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Description

Title of Invention: METHOD FOR PRODUCING WHITE SUGAR, LIGHT BROWN SUGAR AND DARK BROWN SUGAR USING DIRECT RECOVERY PROCESS

Technical Field

The present invention relates to a method for producing white sugar, light brown sugar and dark brown sugar, and more particularly to a method of producing white sugar, light brown sugar and dark brown sugar from the juice extracted from sugar cane by a multi-stage vacuum crystallization process.

Background Art

In general, sugar is produced from sugar canes or beets. In the case of sugar canes, raw sugar is produced by crushing sugar canes and boiling the crushed sugar canes in water to extract sucrose, followed by drying. Because raw sugar consists of crystals of sucrose together with various nutrients and fibers contained in sugar cane, it has the advantage of being rich in minerals and having flavor and fragrance. However, it has a low sugar content, cannot be stored for a long period of time due to fibers and other components, unlike white sugar, and changes in flavor when stored at room temperature for a long period of time, such that it is difficult to distribute raw sugar for commercial purposes.

Removing components other than sucrose from such raw sugar generates what are commonly called "white sugar", "light brown sugar" and "dark brown sugar". These types of sugar are generally produced using the following processes. One obtained by washing and dissolving raw sugar and extracting only sucrose from the raw sugar solution by a carbonatation process, a decoloration process, an ion-exchange refining process, a crystallization process and the like is called "white sugar". One obtained by recrystallizing the sugar solution formed during this white sugar process is "light brown sugar", and "dark brown sugar" can be produced by adding molasses and caramel to the sugar solution. Such types of sugar are widely used not only as seasonings, but also in various industrial applications, including confectionary, bread, brewing, food processing, food preservation, and drinks.

In the prior process for producing sugar, raw sugar is first produced. As shown in FIG. 1, the prior process for producing raw sugar comprises a pressing and juice-extraction step, a lime-addition and filtration step, a concentration/crystallization step, a high-speed centrifugation step, and a drying step.

First, the pressing and juicing step is a step wherein the raw material sugar cane is pressed and juice is extracted from the sugar cane stalk.
The lime-addition and filtration step is a step wherein lime is added to the extracted juice to neutralize the acidity of the juice and the precipitate caused by the addition of lime to the juice, as well as foreign matter or various impurities, are filtered out.

The concentration and crystallization step is a step wherein water is removed from the filtered juice and the juice is concentrated to precipitate the sucrose component.

The high-speed centrifugation step is performed to make raw sugar and consists of separating raw sugar from the slurry resulting from the concentration/crystallization step at a high revolution speed of about 2000-5000 rpm.

After the raw sugar has been produced by the above-described process, another process is carried out to produce white sugar, brown white sugar and dark brown sugar from the raw sugar. FIG. 2 is a flow chart showing a prior-art process of producing white sugar, light brown sugar and dark brown sugar. The prior-art process comprises: a sugar washing process of washing raw sugar in order to produce white sugar from the raw sugar; a melting step that makes the washed raw sugar into an aqueous phase; a carbonation step of introducing carbon dioxide upward into a carbonating tower to form a calcium carbonate precipitate which decolorizes the raw sugar melt and removes impurities from the raw sugar melt; a decoloration step of decolorizing the raw sugar melt; an ion-exchange refining step of obtaining a refined sugar solution; and a step of concentrating and crystallizing the refined sugar solution to obtain white sugar. In addition, brown white sugar and dark brown sugar can be obtained by concentrating the sugar solution remaining after the production of white sugar to form crystals which have a yellow or brown color.

As described above, the prior-art process for producing sugar is a complex process consisting of several steps, and thus has limitations due to the generation of wastewater in the refining step and the use of sub-materials that impose restrictions on reducing the production cost.

Accordingly, the present inventor has studied a production method that can reduce production cost and productivity and, as a result, has found that, when a direct recovery process of recovering white sugar, brown white sugar and dark brown sugar directly without carrying out the process of producing raw sugar is applied, it not only increases production process efficiency, but also is environmentally friendly because it does not generate wastewater, thereby completing the present invention.

**Disclosure of Invention**

**Technical Problem**

The present invention is to provide an environmentally friendly method for producing white sugar, brown white sugar and dark brown sugar, which improves the complexity of the above-described process according to the prior art, overcomes re-
restrictions in reducing the production cost and eliminates the generation of wastewater.

**Solution to Problem**

[13] To achieve the above object, the present invention provides a method for producing white sugar, brown white sugar and dark brown sugar, the method including:

[14] a pressing and juicing step of pressing and juicing sugar cane to extract sugar cane juice (step 1);

[15] a lime-addition and filtration step of adding lime to the juice and removing foreign matter and impurities from the juice (step 2);

[16] a first vacuum crystallization step of vacuum-concentrating the filtered juice in a first vacuum concentrator to produce a first crystal slurry containing sucrose (step 3);

[17] a step of centrifuging the first crystal slurry in a first high-speed centrifuge into a first crystal and a first mother liquor, and recovering the first crystal as dark brown sugar or transferring the first crystal to a second vacuum concentrator (step 4);

[18] a second vacuum crystallization step of vacuum-concentrating the transferred first crystal in the second vacuum concentrator to produce a second crystal slurry containing sucrose (step 5);

[19] a step of centrifuging the second crystal slurry in a second high-speed centrifuge into a second crystal and a second mother liquor, transferring the second liquor to the pressing and juicing step, and drying the second crystal to produce brown white sugar, or transferring the second crystal to a third vacuum concentrator (step 6);

[20] a third vacuum crystallization step of vacuum-concentrating the transferred second crystal in the third vacuum concentrator to produce a third crystal slurry containing sucrose (step 7); and

[21] a step of centrifuging the third crystal slurry in a third high-speed centrifuge into a third crystal and a third mother liquor, transferring the third mother liquor to the first vacuum concentrator, and drying the third crystal to produce white sugar (step 8).

**Advantageous Effects of Invention**

[22] The method for producing white sugar, brown white sugar and dark brown sugar according to the present invention has the following advantages over the prior art.

[23] First, the present invention has the effect of reducing production cost, because it is a direct recovery process of recovering white sugar, brown white sugar and dark brown sugar directly without carrying out a raw-sugar production process. In the prior-art process, white sugar, brown white sugar and dark brown sugar were produced by producing raw sugar from sugar cane through a given process, and then subjecting the raw sugar to a several-step process. It consisted of two production processes separated with respect to the raw sugar, and each production process was complex and increased the production cost. However, because the present invention is a method of producing
white sugar, brown white sugar and dark brown sugar directly from sugar cane without carrying out the raw-sugar production process, it can simplify the production process and can greatly reduce production cost. In addition, the present invention also has the effect of increasing product productivity because the process is more simple.

Second, the method of the present invention is environmentally friendly, because a refining process that generates wastewater is not carried out. In the prior-art process, white sugar, brown white sugar and dark brown sugar were produced from raw sugar that had been produced before, in which a refining process of, for example, washing the raw sugar to be used to produce such types of sugar, was necessarily required. However, in the present invention, this refining process is not carried out, because white sugar, brown white sugar and dark brown sugar are produced directly from sugar cane without producing raw sugar. Thus, wastewater that is generated in the refining process and the use of sub-materials in the refining process are fundamentally eliminated. Also, in the present invention, because a liquid that is separated after washing with purified water is a mother liquor that is recovered in the process, no wastewater is generated. This is advantageous in environmental terms and can result in the effect of reducing equipment investment which enhances cost competitiveness.

**Brief Description of Drawings**

FIG. 1 is a flow chart showing a process of producing raw sugar from sugar cane;
FIG. 2 is a flow chart showing a process of producing white sugar, brown white sugar and dark brown sugar from raw sugar;
FIG. 3 is a flow chart showing a method of producing white sugar, brown white sugar and dark brown sugar from sugar cane according to the present invention; and
FIG. 4 is an overall flow chart showing a method of producing white sugar, brown white sugar and dark brown sugar from sugar cane according to the present invention.

<Description of main reference numerals used in the drawings>

P: presser
FP: filter press
W: purified water tank
C1: first vacuum concentrator
C2: second vacuum concentrator
C3: third vacuum concentrator
S1: first high-speed centrifuge
S2: second high-speed centrifuge
S3: third high-speed centrifuge

**Best Mode for Carrying out the Invention**

Hereinafter, the production method of the present invention will be described in
detail with reference to FIGS. 3 and 4. As shown in FIG. 3, the method of producing white sugar, brown white sugar and dark brown sugar according to the present invention comprises a step of pressing and juicing sugar cane to extract juice; a lime-addition and filtration step, a first vacuum crystallization step, a second vacuum crystallization step, a third vacuum crystallization step, a high-speed centrifugation step, and a drying step. Also, the overall flow of the production method according to the present invention is shown in FIG. 4.

Step 1 of the production method according to the present invention is a pressing and juicing step of pressing and juicing sugar cane to extract sugar cane juice. In this step, sugar cane cut to a given size is placed in a conventional presser and/or juicer in which juice is extracted from the sugar cane.

Step 2 is a lime-addition and filtration step of adding lime to the juice and removing foreign materials and impurities from the juice. In this step, the acidity of the juice obtained in step 1 is lowered, and foreign matter is removed.

The sugar cane juice cannot be used as it is, because it has a high acidity and contains a large amount of foreign matter. For this reason, lime is added to neutralize the juice, and foreign matter and impurities are filtered out. The filtration of foreign matter and impurities can be performed using a conventional filter, for example, a filter press. By carrying out the lime-addition and filtration step, the sucrose content of the juice can be increased to preferably 80% or more based on the dry weight of the juice.

Step 3 is a first vacuum crystallization step of vacuum-concentrating the filtered juice in a first vacuum concentrator to produce a first crystal slurry containing sucrose. In this step, a first sucrose crystal is produced from the juice.

When the filtered juice is transferred to a reactor in the first vacuum concentrator and vacuum-concentrated by controlling the temperature and vacuum level within the first vacuum concentrator, the saturation degree of the juice is increased so that a sucrose crystal is precipitated, thereby obtaining a first crystal slurry. Preferably, the temperature and vacuum level within the first vacuum concentrator are maintained at 55-90 °C and 500-800 mmHg, respectively, in order to facilitate the formation of the slurry. Also, in order to facilitate the production of the crystal, a seed is preferably added in an amount of 10-200 ppm relative to the sucrose content of the juice, thereby obtaining the first crystal slurry.

Also, because the decoloration rate and refining degree of the crystal slurry vary depending on the temperature of the purified water, the method of the present invention preferably additionally comprises a step of washing the produced first crystal slurry with purified water of 30-40 °C. More preferably, the method of the present invention additionally comprises washing the first crystal slurry by spraying purified steam at a steam pressure of 0.5-2.0 kg/cm².
Step 4 is a step of centrifuging the first crystal slurry in a first high-speed centrifuge into a first slurry and a first mother liquor, and recovering the first crystal as dark brown sugar or transferring the first crystal to a second vacuum concentrator. The first mother liquor is the final byproduct molasses that can be marketed for use as a carbon source in fermentation processes in the bio-industry. Namely, as shown in FIG. 4, the first crystal slurry is separated into dark brown sugar and a mother liquor (a final byproduct molasses) by a high-speed centrifuge SI, and the separated dark brown sugar is recovered as a product or transferred to a second crystallization step. The mother liquor separated in this step is the final byproduct of the production method of the present invention.

As used herein, the term "dark brown sugar" means sugar that has a low refining degree, is dark brown in color, intensely fragrant, and moist in nature.

When the first crystal slurry is centrifuged, it can be separated into crystals and a mother liquor. Preferably, the centrifugation of the first crystal slurry is performed at a temperature of 55-65 °C and a revolution speed of 2000-3000 rpm. The separated crystal can be dried to produce dark brown sugar.

The separated and recovered crystal is transferred to a second vacuum concentrator and used to produce brown white sugar and/or white sugar. The separated and recovered crystal can be transferred to a reactor equipped with a vacuum concentrator with a screw conveyor, and hot water is passed through the screw conveyor, such that the crystal remaining in the conveyor is completely transferred to the second vacuum concentrator. When hot water is passed through the screw conveyor, the crystal remaining in the screw conveyor can be melted and transferred, and thus no crystal will remain in the conveyor. It is preferable to use hot water of 80-90 °C so as to sufficiently melt the remaining crystal.

If brown white sugar or white sugar is to be produced in an amount larger than dark brown sugar, it is preferable to transfer the separated first crystal to the second vacuum concentrator rather than recovering the first crystal as dark brown sugar. Accordingly, the production rate of each type of sugar can be easily controlled in consideration of market demand.

Step 5 is a second vacuum crystallization step of vacuum-concentrating a solution containing the transferred crystal in the second vacuum concentrator to produce a second crystal slurry containing sucrose. In this step, a mixture of the crystal transferred to the second vacuum concentrator and hot water is vacuum-concentrated to produce the second crystal slurry.

When the mixture is vacuum-concentrated by controlling the temperature and vacuum level within the second vacuum concentrator, the saturation degree of the juice is increased so that sucrose crystals are precipitated, thereby obtaining a second crystal.
slurry. Preferably, the temperature and vacuum level within the second vacuum concentrator are maintained at 55-90 °C, and more preferably 55-75 °C, and 500-800 mmHg, respectively, in order to facilitate the formation of the slurry. Also, in order to facilitate the formation of the slurry, it is preferable to add and control hot water of 55-90 °C depending on the particle size distribution and shape of the crystal in the metastable region of sucrose. The term "metastable region of sucrose" refers to a region which is present in a supersaturation region in specific temperature and concentration ranges on the sucrose solubility curve and in which only crystal growth occurs and crystal production does not occur.

Also, because the decoloration rate and refining degree vary depending on the temperature of purified water, the method of the present invention preferably additionally comprises a step of washing the produced second crystal slurry with purified water of 60-70 °C. More preferably, the method of the present invention additionally comprises a step of washing the second crystal slurry by spraying purified steam at a pressure of 0.5-2.0 kg/cm².

Step 6 is a step of centrifuging the second crystal slurry in a second high-speed centrifuge into a second crystal and a second mother liquor, transferring the second mother liquor to the pressing and juicing step, and drying the second crystal to produce brown white sugar or transferring the second crystal to a third vacuum concentrator.

As used herein, the term "brown white sugar" means brown sugar which has some fragrance and color and a refining degree higher than that of dark brown sugar.

When the second crystal slurry is centrifuged, it can be separated into crystals and a mother liquor. Preferably, the centrifugation is carried out at a temperature of 55-65 °C and a revolution speed of 2000-3000 rpm. The separated mother liquor still contains sucrose, and thus when it is transferred to the pressing and juicing step, the total recovery rate of sucrose can be increased, thus reducing production cost.

The separated and recovered crystal may be dried to produce brown white sugar or may be transferred to a third vacuum concentrator. The separated and recovered crystal can be transferred to a reactor equipped with a vacuum concentrator by using a screw conveyor, and hot water is passed through the screw conveyor, such that the crystal remaining in the screw conveyor is completely transferred to the third vacuum concentrator. When hot water is passed through the screw conveyor, the crystal remaining in the conveyor can be melted with the hot water and transferred, and thus no crystals will remain in the conveyor. It is preferable to use hot water of 80-90°C so as to sufficiently melt the remaining crystals.

If white sugar is to be produced in an amount larger than brown white sugar, it is preferable to transfer the separated second crystal to the third vacuum concentrator rather than recovering the second crystal as brown white sugar. Accordingly, the
production rate of each type of sugar can be easily controlled to match market demand.

Step 7 is a third vacuum crystallization step of vacuum-concentrating a solution containing the transferred second crystal in the third vacuum concentrator to produce a third crystal slurry containing sucrose. In this step, a mixture of the crystal transferred to the third vacuum concentrator and hot water is vacuum-concentrated to produce the third crystal slurry.

When the mixture is vacuum-concentrated by controlling the temperature and vacuum level within the third vacuum concentrator, the saturation degree of the juice is increased so that sucrose crystals precipitate, thereby obtaining a third crystal slurry. Preferably, the temperature and vacuum level within the third vacuum concentrator are maintained at 55-90 °C, and more preferably 55-65 °C, and 500-800 mmHg, respectively. Also, in order to facilitate the formation of the slurry, it is preferable to add and control hot water of 55-90 °C depending on the particle size distribution and shape of the crystal in the metastable region of sucrose.

Also, because the decoloration rate and refining degree vary depending on the temperature of purified water, the method of the present invention preferably additionally comprises a step of washing the produced third crystal slurry with purified water of 80-90 °C. More preferably, the method of the present invention additionally comprises a step of washing the third crystal slurry by spraying purified steam at a pressure of 0.5-2.0 kg/cm².

Step 8 is a step of centrifuging the third crystal slurry in a third high-speed centrifuge into a third crystal and a third mother liquor, transferring the third mother liquor to the first vacuum concentrator, and drying the third crystal to produce white sugar.

As used herein, the term "white sugar" means sugar having the highest purity.

When the third crystal slurry is centrifuged, it can be separated into crystals and a mother liquor. The centrifugation is preferably carried out at a temperature of 55-65 °C and a revolution speed of 2000-3000 rpm. The separated and recovered crystals may be dried to produce high-purity white sugar having a purity of 99.9%, and the separated and recovered mother liquor is transferred to the first vacuum crystallization step in order to increase the recovery rate of sucrose in the process. The white sugar produced according to the present invention can have a very high purity, because the sugar cane juice is subjected at least three times to the crystallization process.

**Mode for the Invention**

Hereinafter, a preferred example will be presented to aid in the understanding of the present invention. It is to be understood, however, that the following example is presented to facilitate the understanding of the present invention without limiting the scope of the present invention.
Example: Production of white sugar, brown white sugar and dark brown sugar using direct recovery process

Three vacuum concentrators were used. Slurry in the first vacuum concentrator was maintained at a temperature of 55-90 °C and a vacuum level of 500-760 mmHg, slurry in the second vacuum concentrator at a temperature of 55-75 °C and a vacuum level of 600-760 mmHg, and slurry in the third vacuum concentrator at a temperature of 55-65 °C and a vacuum level of 700-760 mmHg. In each concentration step, hot water of 55-90 °C was added depending on the growth rate, particle size and shape of the crystals. Because the temperature and the pressure were not fixed at constant values, but changed during the process, the temperature and the pressure were controlled so as to be maintained within the above-specified ranges.

The crystal slurry formed in each concentration step was transferred to a high-speed centrifuge, and the first crystal slurry was washed by spraying purified water of 30 °C for 3 seconds. After spraying, the separated crystals were continuously sent in a given amount to a dryer where they were dried at 60 °C, thus obtaining first crystals. The results of analysis of the obtained first crystals are shown in Table 1 below.

The second crystal slurry was washed by spraying purified water of 60 °C for 3 seconds. After spraying, the separated crystals were continuously sent in a given amount to a dryer where they were dried at 60 °C, thus obtaining second crystals. The results of analysis of the obtained second crystals are shown in Table 1 below.

The third crystal slurry was sprayed with purified water of 80 °C for 3 seconds and then sprayed with purified steam at a pressure of 1 kg/cm² for 1 second. After spraying, the separated crystals were continuously sent in a given amount to a dryer where they were dried at 60 °C, thus obtaining third crystals. The results of analysis of the obtained third crystals are shown in Table 1 below.

Table 1
<table>
<thead>
<tr>
<th>Crystal Type</th>
<th>Purity(%)(^a)</th>
<th>Invert Sugar(%)(^b)</th>
<th>Yield(%)(^c)</th>
<th>T(%)(^d)</th>
<th>Ash(%)(^e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First crystal (dark brown sugar)</td>
<td>97.5</td>
<td>1.5</td>
<td>80</td>
<td>70</td>
<td>1.0</td>
</tr>
<tr>
<td>Second crystal (brown white sugar)</td>
<td>99.3</td>
<td>0.2</td>
<td>65</td>
<td>88</td>
<td>0.5</td>
</tr>
<tr>
<td>Third crystal (white sugar)</td>
<td>99.5</td>
<td>-</td>
<td>55</td>
<td>99</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^a\) Purity: the purity of crystal separated as sucrose and dried (determined by HPLC).  
\(^b\) Invert sugar: the content of invert sugar (glucose & fructose) separated as sucrose and dried (determined by HPLC).  
\(^c\) Yield: the ratio of the content of sucrose obtained in crystal form relative to the content of sucrose in juice in each step (HPLC content analysis & weight ratio of obtained crystal).  
\(^d\) T(%): the color value of crystal sucrose after dissolution (420 nm spectrophotometer).  
\(^e\) Ash(%): the content of ash in crystal sucrose (Korean food code method).
Claims

[Claim 1] A method for producing white sugar, brown white sugar and dark brown sugar, the method comprising:
a pressing and juicing step of pressing and juicing sugar cane to extract sugar cane juice;
a lime-addition and filtration step of adding lime to the juice and removing foreign matter and impurities from the juice;
a first vacuum crystallization step of vacuum-concentrating the filtered juice in a first vacuum concentrator to produce a first crystal slurry containing sucrose;
a step of centrifuging the first crystal slurry in a first high-speed centrifuge into a first crystal and a first mother liquor, and recovering the first crystal as dark brown sugar or transferring the first crystal to a second vacuum concentrator;
a second vacuum crystallization step of vacuum-concentrating the transferred first crystal in the second vacuum concentrator to produce a second crystal slurry containing sucrose;
a step of centrifuging the second crystal slurry in a second high-speed centrifuge into a second crystal and a second mother liquor, transferring the second liquor to the pressing and juicing step, and drying the second crystal to produce brown white sugar, or transferring the second crystal to a third vacuum concentrator;
a third vacuum crystallization step of vacuum-concentrating the transferred second crystal in the third vacuum concentrator to produce a third crystal slurry containing sucrose; and
a step of centrifuging the third crystal slurry in a third high-speed centrifuge into a third crystal and a third mother liquor, transferring the third mother liquor to the first vacuum concentrator, and drying the third crystal to produce white sugar.

[Claim 2] The method of claim 1, wherein the temperature and vacuum level within the vacuum concentrator in each of the first crystallization step, the second vacuum crystallization step and the third vacuum crystallization step are maintained at 55-90 °C and 500-800 mmHg, respectively.

[Claim 3] The method of claim 1, wherein a seed is added to the juice in the first vacuum crystallization step in an amount of 10-200 ppm relative to the sucrose content of the juice.
[Claim 4] The method of claim 1, wherein the centrifugation is carried out at a temperature of 55-65 °C and a revolution speed of 2000-3000 rpm.

[Claim 5] The method of claim 1, wherein the first crystal separated from the first crystal slurry is transferred to the second vacuum concentrator using a screw conveyor, and crystals remaining in the screw conveyor are transferred to the second vacuum concentrator by passing hot water through the screw conveyor.

[Claim 6] The method of claim 1, wherein the second crystal separated from the second crystal slurry is transferred to the third vacuum concentrator using a screw conveyor, and a crystals remaining in the screw conveyor are transferred to the third vacuum concentrator by passing hot water through the screw conveyor.

[Claim 7] The method of claim 5 or 6, wherein the hot water has a temperature of 80-90 °C.

[Claim 8] The method of claim 1, wherein hot water of 55-90 °C is added to the first vacuum concentrator, the second vacuum concentrator or the third vacuum concentrator depending on the particle size distribution and shape of the first crystal, the second crystal or the third crystal, thereby controlling the temperature of the first vacuum concentrator, the second vacuum concentrator or the third vacuum concentrator.

[Claim 9] The method of claim 1, further comprising, in the first vacuum crystallization step, a step of washing the produced first crystal slurry with purified water of 30-40 °C.

[Claim 10] The method of claim 1, further comprising, in the second vacuum crystallization step, a step of washing the produced second crystal slurry with purified water of 60-70 °C.

[Claim 11] The method of claim 1, further comprising, in the third vacuum crystallization step, a step of washing the produced third crystal slurry with purified water of 80-90 °C.

[Claim 12] The method of any one of claims 9 to 11, further comprising a step of washing the crystal slurry by spraying purified steam at a steam pressure of 0.5-2.0 kg/cm².
[Fig. 1]

sugar cane

pressing and juicing step

lime-addition and filtration step

concentration/crystallization step

high-speed centrifugation step

drying step

raw sugar
[Fig. 3]

sugar cane

↓

pressing and juicing step

↓

lime-addition and filtration step

↓

first vacuum crystallization step

↓

second vacuum crystallization step  high-speed centrifugation step

↓

third vacuum crystallization step  drying step

↓

white sugar  brown white sugar  dark brown sugar