(51) International Patent Classification 6:
A23l. 3/36, A23B 9/10

(11) International Publication Number: WO 95/12324
(43) International Publication Date: 11 May 1995 (11.05.95)

(21) International Application Number: PCT/JP94/01842
(22) International Filing Date: 1 November 1994 (01.11.94)

(30) Priority Data:
5/297308 2 November 1993 (02.11.93) JP
6/33058 4 February 1994 (04.02.94) JP

(71) Applicants (for all designated States except US):

(72) Inventors;

(74) Agent: TAKAHASHI, Masahisa; 8-13-901, Minato 1-chome, Chuo-ku, Tokyo 104 (JP).


Published With international search report.

Title: PROCESS OF FREEZING SHUSI OR BOILEE RICE CONTAINING FOOD

Abstract

A process for freezing sushi, boiled rice or processed food containing boiled rice is described. The method permits to achieve substantially the same quality after natural thawing or thawing in an electric oven as before the freezing step. In one embodiment the process consists of three steps: firstly the temperature of the product is reduced to 0 - -4 °C, secondly the temperature is reduced until having passed the maximum ice generation temperature range (up to -10 °C), lastly the food is cooled to at least -15 °C. The temperature gradient and freezing time in the second step being greater than in the first step. In another embodiment of the present invention the freezer temperature is preset to 0 - -10 °C. When freezing procedure starts, the temperature of the freezer is reduced to -15 °C within 10 to 20 minutes with a temperature gradient of 1 to 2 °C/min., then temperature is changed to -10 to -20 °C, and in the third step to -30 to -45 °C with a linear temperature gradient of 0.5 to 1 °C/min. Freezing time in the second step is about 15 min.
FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Austria</td>
<td>GB</td>
<td>United Kingdom</td>
<td>MR</td>
<td>Mauritania</td>
</tr>
<tr>
<td>AU</td>
<td>Australia</td>
<td>GE</td>
<td>Georgia</td>
<td>MW</td>
<td>Malawi</td>
</tr>
<tr>
<td>BB</td>
<td>Barbados</td>
<td>GN</td>
<td>Guinea</td>
<td>NE</td>
<td>Niger</td>
</tr>
<tr>
<td>BE</td>
<td>Belgium</td>
<td>GR</td>
<td>Greece</td>
<td>NL</td>
<td>Netherlands</td>
</tr>
<tr>
<td>BF</td>
<td>Burkina Faso</td>
<td>HU</td>
<td>Hungary</td>
<td>NO</td>
<td>Norway</td>
</tr>
<tr>
<td>BG</td>
<td>Bulgaria</td>
<td>IE</td>
<td>Ireland</td>
<td>NZ</td>
<td>New Zealand</td>
</tr>
<tr>
<td>BJ</td>
<td>Benin</td>
<td>IT</td>
<td>Italy</td>
<td>PL</td>
<td>Poland</td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>JP</td>
<td>Japan</td>
<td>PT</td>
<td>Portugal</td>
</tr>
<tr>
<td>BY</td>
<td>Belarus</td>
<td>KE</td>
<td>Kenya</td>
<td>RO</td>
<td>Romania</td>
</tr>
<tr>
<td>CA</td>
<td>Canada</td>
<td>KG</td>
<td>Kyrgyzistan</td>
<td>RU</td>
<td>Russian Federation</td>
</tr>
<tr>
<td>CF</td>
<td>Central African Republic</td>
<td>KP</td>
<td>Democratic People’s Republic of Korea</td>
<td>SD</td>
<td>Sudan</td>
</tr>
<tr>
<td>CG</td>
<td>Congo</td>
<td>KR</td>
<td>Republic of Korea</td>
<td>SE</td>
<td>Sweden</td>
</tr>
<tr>
<td>CH</td>
<td>Switzerland</td>
<td>KZ</td>
<td>Kazakhstan</td>
<td>SI</td>
<td>Slovenia</td>
</tr>
<tr>
<td>CI</td>
<td>Côte d’Ivoire</td>
<td>LK</td>
<td>Sri Lanka</td>
<td>SK</td>
<td>Slovakia</td>
</tr>
<tr>
<td>CM</td>
<td>Cameroon</td>
<td>LU</td>
<td>Luxembourg</td>
<td>SN</td>
<td>Senegal</td>
</tr>
<tr>
<td>CN</td>
<td>China</td>
<td>LV</td>
<td>Latvia</td>
<td>SD</td>
<td>Chad</td>
</tr>
<tr>
<td>CS</td>
<td>Czechoslovakia</td>
<td>MC</td>
<td>Monaco</td>
<td>TT</td>
<td>Togo</td>
</tr>
<tr>
<td>CZ</td>
<td>Czech Republic</td>
<td>MD</td>
<td>Republic of Moldova</td>
<td>TJ</td>
<td>Tajikistan</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>MG</td>
<td>Madagascar</td>
<td>UA</td>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>DK</td>
<td>Denmark</td>
<td>ML</td>
<td>Mali</td>
<td>US</td>
<td>Ukraine</td>
</tr>
<tr>
<td>ES</td>
<td>Spain</td>
<td>MN</td>
<td>Mongolia</td>
<td>UZ</td>
<td>United States of America</td>
</tr>
<tr>
<td>FI</td>
<td>Finland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA</td>
<td>Gabon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PROCESS OF FREEZING SUSHI OR BOILED RICE CONTAINING FOOD

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a process of freezing sushi, boiled rice or processed food with boiled rice as main component.

Among varieties of sushi which can be frozen by the process according to the invention is nigiri-sushi (or edomae-sushi) 1 as shown in Fig. 19(A). A piece of this food is prepared by grasping an adequate amount of boiled rice 1a with vinegar into a mouthful oval piece, then putting a piece of fish, shellfish, shrimp, etc. 1b on this rice piece and then adjusting the overall shape of the food by lightly gripping the same. Another variety of sushi is oshi-sushi 3 as shown in Fig. 19(B). This food is prepared by filling a rectangular wooden frame of about 20 cm x 10 cm with boiled rice with vinegar 3a, then putting a piece or pieces of fish, shellfish, shrimp, etc. 3b on the rice, then pressing the resultant food from above with a wooden lid for shape adjustment, and then cutting the food into mouthful.
pieces. A further variety of sushi is inari-sushi 4 as shown in Fig. 19(C). This food is prepared by using aburage (or fried sliced tofu) 4b prepared by frying rectangular sliced tofu in oil after water draining. Each aburage piece 4b is cut into two halves, and these aburage halves are boiled using sweet shoyu. Then, each boiled aburage half is opened from the cut side into a sack-like form, and then charging boiled rice 4a with vinegar into the open boiled aburage half. In this way, a piece of inari-sushi is obtained. A further variety of sushi is maki-sushi 12 as shown in Fig. 19(B). As shown, a piece of this food has a circular sectional profile, and it is also called norimaki 12 or futomaki 13. It comprises a central ingredient part 12b, 13b which may be a piece or pieces of fish, baked egg, cucumber or like vegetables, etc., a boiled rice part 12a, 13a surrounding the ingredient part and having a predetermined thickness, and paper-like toasted laver 12c, 13c surrounding the boiled rice part. (The norimaki 12 and futomaki 13 are different in that in the norimaki 12 only a single kind of ingredient is used for the central ingredient part, while the futomaki 13 uses a plurality of different ingredients, the former being about 3 cm in diameter while the latter being about 5 cm.) Particularly, the invention concerns a process of freezing
sushi, which permits substantially the same quality as non-frozen sushi to be obtained after natural thawing.

Further, the invention is applicable to a process of freezing boiled rice or processed food with boiled rice as main component, permitting substantially the same quality as non-frozen food to be obtained after natural thawing. Among varieties of this type of food, there is boiled cleaned or uncleaned rice as shown in Fig. 20(A). The boiled cleaned rice is prepared by boiling cleaned rice or white rice grains, which are obtained by polishing off surface portions of uncleaned rice after hulling. The boiled uncleaned rice is prepared by boiling uncleaned rice in a high pressure oven. A further variety of the food is sekihan 6 as shown in Fig. 20(B). This food is prepared by boiling of steaming glutinous rice with azuki bean, making the rice itself pink. A further variety of the food is rice cake 7 as shown in Fig. 20(C). This food is prepared by squeezing steamed glutinous rice into a grain-free state. A further variety of the food is onigiri 8 utilizing boiled rice as shown in Fig. 21(A). This food is a substantially triangular piece of boiled rice 8a formed with both hands or with a wooden frame. If desired, pickled fish egg, pickled plum, etc. may be provided inside. Further, onigiri may have a cover of paper-like laver 8b. A further variety of the food is takikomi gohan (combination
boiled rice) as shown in Fig. 21(B). This feed is prepared by boiling rice together with sliced meat, vegetables, fish, shellfish, etc. and also with shoyu or like seasoning.

A further variety is fried rice prepared by frying boiled rice with slices of meat, vegetables, fish, shellfish, etc. A further variety of the food is okowa (combination steamed glutinous rice) similar to the takikomi gohan 9. This food is prepared by steaming glutinous rice together with meat, vegetables, fish, shellfish, etc. and also with shoyu or like seasoning. Sometimes, the materials are steamed in a state that they are wrapped in bamboo bud skin. A further variety of the food is pilaf which is prepared by boiling rice together with meat, vegetables, fish, shellfish, etc. and also with olive oil, Safran or like seasoning. A further variety of the food is ohagi 11 as shown in Fig. 22(A). This food is a mouthful ball-like boiled glutinous rice piece 11a in sweet boiled azuki bean 11b. A further variety of the food is chirashi as shown in Fig. 21(C), which is prepared by mixing boiled rice with vinegar and sliced fish, baked egg, vegetables such as cucumber, etc.. A further variety of the food is beef bowl or other bowls, which is prepared by filling a bowl with rice and then putting cooked meat, egg, curry, etc. on the rice. There are further varieties of the processed food, the volume of which is
mainly occupied by boiled rice, for instance curry rice.

Description of the Prior Art

Among recent frozen foods are fresh foods and cooked foods, and boiled rice, rice cake, sushi and the like are not exceptions. These conventional frozen foods, however, have their texture destroyed when they are frozen. Therefore, when they are thawed, they give a great deal of liquid drops, giving rise to great differences of smoothness and sense of touch compared to fresh foods.

Particularly, frozen nigiri-sushi presents such problems as escapement of vinegar from the rice ball part, which is constituted by boiled rice with vinegar and carries a piece of fish or the like, hard rice grains due to loss of stickiness, discoloring of ingredients, loss of taste, etc..

Also, boiled rice or processed food with boiled rice as main component, when frozen and thawed in the usual way, results in hard rice grains due to loss of stickiness and therefore in unsatisfactory taste, sense of eating, etc..

To solve the above problems, various processes of freezing sushi or boiled rice or the like have been proposed.

For example, Japanese Patent Laid-Open Publication No. Sho 61-260843 (Prior Art Example 1) shows a freezing process, in which maki-sushi is frozen quickly in a state of
being wrapped in transparent film to a temperature of -40 to -70°C.

Also, Japanese Patent Laid-Open Publication No. Hei 2-100643 (Prior Art Example 2) shows a method of manufacturing frozen sushi, in which washed rice is boiled by adding vinegar to additive liquid for extraction of branched cyclodextrine for vinegar escapement prevention and organic phosphate, amino acid, etc. for preventing the hardening and oxidation of the rice to obtain boiled rice with vinegar. Sushi is then prepared with the boiled rice and ingredients, and the sushi thus prepared is frozen momentarily in contact with liquid nitrogen gas in a short period of time (i.e., 18 to 20 min.).

Further, Japanese Patent Laid-Open Publication No. Sho 5-38266 (Prior Art Example 3) shows a process of producing frozen boiled rice including frozen sushi, in which rice boiled in the usual way is cooled down to 25 to 40°C and then formed to a predetermined shape, then frozen quickly in a freezer preliminarily cooled down to -40 to -50°C by blowing liquified gas against the rice while maintaining a constant reduced pressure in the freezer, and then frozen continually by passing a maximum ice generation temperature range in a short period of time (i.e., 3 min.), thus obtaining substantially the same temperature of the superficial
and central parts of the formed rice.

The Prior Art Example 1, however, is a special process of freezing maki-sushi and can not be applied to nigiri-sushi with a piece of fish, shellfish, cooked egg (hereinafter referred to as sushi raw materials) put on rice ball. Besides, the process dictates wrapping each sushi piece, which is very cumbersome.

The Prior Art Example 2 requires especially prepared additives or additive liquids for the prevention of the escapement of vinegar from boiled rice with vinegar and the hardening and oxidation of the boiled rice. The tastes of such additives or the like cause generation of bitterness, thus leading to great deterioration of the taste.

In either of the above techniques, a significant problem is posed by the quick freezing sushi by passing the maximum ice generation temperature range (-1 to -5°C) in a minimum period of time for texture destruction prevention in the freezing process. A freezing curve which is obtainable in case of quickly passing the maximum ice generation temperature range for quick freezing, for the rice ball part as shown in Fig. 3, does not always provide for good taste, and the quality of food is deteriorated extremely compared to non-frozen sushi.

A further problem which is posed in case of frozen
sushi is that the technique of thawing is usually very difficult. This is based on the fact that the sushi raw material part (e.g., fish piece) and rice ball part require different thawing times in case of using an electronic oven, for instance, for the thawing. Therefore, setting the thawing time for the raw material results in that most part of the rice ball is still in the frozen state. If the thawing time is set for the rice ball part, on the other hand, the sushi raw material is excessively heated by the heat of the electronic oven during the thawing of sushi.

Accordingly, a technique of high frequency heating sushi raw materials in a state of being wrapped in aluminum foil, as disclosed in Japanese Patent Laid-Open No. Sho 63-24864. However, it is practically impossible to separate the sushi raw material part and rice ball part of the frozen sushi. Basically, therefore, a freezing technique is necessary, which permits the same quality as non-frozen sushi to be obtained by natural thawing.

Meanwhile, it has been proposed to vacuum seal boiled cleaned rice or the like and water in a resin film bag for steaming under pressure and subsequent freezing and thawing, as disclosed in Japanese Patent Laid-Open Publication No. Sho 60-16560. Such a freezing process, in which rice is steamed under pressure in a state of being packed with water,
is not applicable to onigiri or like processed food.

Further, there is a commonly called loose rice freezing process, in which boiled rice is frozen in a state of being made loose such that the individual grains are distinct from one another, as disclosed in, for instance, Japanese Patent Laid-Open Publication No. Sho 62-253350. Such freezing process provides for rice with the individual grains distinct from one another due to lack of stickiness. Such rice, although suited as the material of pilaf, is unsuited for eating it directly after thawing. Further, the rice can not be utilized directly after thawing as a product for sales in shops.

Further, there is a technique of freezing rice that has been boiled with an organic acid or a derivative thereof, as disclosed in Japanese Patent Laid-Open No. Sho 60-172262. According to such technique, the taste is deteriorated by the additive.

SUMMARY OF THE INVENTION

An object of the invention, in view of the above technical problems, is to provide a process of freezing sushi, which permits substantially the same taste and sense of eating as non-frozen sushi to be obtained with frozen sushi.
Another object of the invention is to provide a process of freezing sushi, which permits substantially the same taste and sense of eating as non-frozen sushi to be obtained even after natural thawing.

A further object of the invention is to provide a process of freezing sushi, which permits substantially the same taste and sense of eating as non-frozen sushi to be obtained even when individual sushi pieces are frozen without wrapping one by one but in a state of being held in rows in vessels.

A still further object of the invention is to provide a process of freezing boiled rice, such as boiled cleaned rice, boiled uncleaned rice, sekihan rice, rice cake, etc., or processed food utilizing such boiled rice, such as onigiri, combination boiled rice, fried rice, chirashi, ohagi, okowa, etc., which permits the same quality as that before freezing to be obtained after thawing.

A yet further object of the invention is to provide a process of freezing boiled rice obtained in the usual way and/or processed food utilizing such boiled rice, which permits the same taste and sense of eating as before freezing to be obtained after thawing even when the food is frozen and naturally thawed in a packed state or in a state of being held plastic vessels or the like.
A still another object of the invention is to a process of freezing boiled rice obtained in the usual way and/or processed food utilizing such boiled rice without use of any additive, which permits substantially the same taste and sense of eating before freezing to be obtained after freezing and natural thawing.

A yet another object of the invention is to provide a process of freezing sushi, boiled rice or processed food with boiled rice as main component, which permits the manufacturer to obtain food with good reproducibility and also permits the consumer to obtain good taste and substantially the same quality as fresh processed food before freezing.

To attain the above objects of the invention, there is provided a process of freezing sushi, such as nigiri-sushi, inari-sushi, maki-sushi, etc., which comprises disposing the sushi, in a state of being held alone or mixed in vessels, in a freezer, and then starting freezing, the freezing comprising a first freezing step of reducing the temperature of the rice ball part of the sushi from the initial temperature at the start of freezing to the freezing point (0 to -4° C), a second freezing step of reducing the temperature until passing of a maximum ice generation temperature range from the freezing point to about -10° C while maintaining the same range for a predetermined period of time, and
a third freezing step of reducing the temperature to -15°C or below, preferably -20°C or below, more preferably -30°C or below, after passing of the maximum ice generation temperature range, and the temperature gradient in the first freezing step being set to be greater than the temperature gradient in the second freezing step, the time of the second freezing step being set to be longer than the time of the first freezing step, specifically at least the time of the second freezing step being set to about 15 to 35 min.

In this case, the freezing end temperature in the third freezing step may be -30°C or below purely in the quality standpoint and may be -15°C or below without any problem. In view of the necessity of increasing the temperature of the product in a packing step subsequent to the end of freezing, it is suitable to end the freezing with the product at a temperature of -20 to -30°C.

Further, the temperature gradient in the third freezing step until reaching of -20 to -30°C after passing of the maximum ice generation temperature range is suitably set to be substantially equal to or greater than the temperature gradient in the first freezing step.

Specifically, when freezing sushi at normal temperature, i.e., around 20°C, it is suitable to set the temperature gradient in the first freezing step to about 1 to 2.5°C.
C/min., preferably about 1 to 2° C/min., the temperature gradient in the second freezing step to about 0.5° C/min. or below, preferably 0.3° C/min. or below, and the temperature gradient in the third freezing step to about 1 to 3° C/min., preferably 1.5 to 2.5° C/min.

If the freezing time in the third freezing step down to -20 to -30° C after passing of the maximum ice generation temperature range is too short, the intended effect can not be attained. Accordingly, when executing the third freezing step down to -30° C, it is suitable to set the time of this step to about 10 min. or above, preferably 10 to 20 min..

The freezer temperature, i.e., the temperature of the freezing space, will now be described on the basis of freezing curve. In case when, for instance, disposing nigiri-sushi, maki-sushi, etc., such that pieces of sushi are held without each being wrapped in rows in vessels, in a freezer and then preliminarily cooling down the freezer to a temperature of about 0 to -15° C, preferably about -5 to -10° C, the freezing comprises a first freezer temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature to about -30° C in about 5 to 25 min. from the start of freezing, and a second freezer temperature reduction step of reducing the freezer temperature to a lower temperature. In this case, the temperature gradient
in the first freezer temperature reduction step is set to the greater than the temperature gradient in the second freezer temperature reduction step, and the time until passing of the maximum ice generation temperature range of 0 to -10° C of the rice part of the sushi is set to 15 to 35 min., preferably 15 to 25 min..

In this case, it is suitable to set the temperature gradient and time of the first freezer temperature reduction step to about 1 to 3° C/min., preferably 1 to 2° C/min., and about 10 to 20 min., respectively, and set the temperature gradient in the second freezer temperature reduction step to 1° C/min. or below, preferably about 2.0 to 0.5° C/min..

(As understood from the foregoing description, the temperatures that are set for the first to third freezing steps refer to the temperature of the rice ball part, particularly the central part thereof, while those for the first and second freezer temperature reduction steps refer to the freezer temperature.)

Specifically, when freezing nigiri- or maki-sushi, the freezer is preliminarily cooled down to the above temperature, and then the sushi is disposed in a stage of being held in rows in vessels in the freezer for freezing. The freezing in this case comprises a first freezer temperature reduction step of reducing the freezer temperature from the
preliminary cooling temperature to about -30° C in about 15 to 25 min., and a second freezer temperature reduction step of reducing the freezer temperature to a lower temperature. It is suitable in this case to set the temperature gradient in the first freezer temperature reduction step to be greater than the temperature gradient in the second freezer temperature reduction step and set the time until passing (or of maintenance) of the maximum ice generation temperature range of 0 to -10° C, more specifically -3 to -6° C, to 15 to 25 min., preferably 15 to 20 min..

The temperature gradient will now be described. In case of freezing nigiri-sushi at normal temperature, i.e., about 20° C, it is suitable to set the temperature gradient in and time of the first freezer temperature reduction step from the preliminary cooling temperature of -10° C to -30° C to 1 to 2° C/min. and about 20 min., respectively, and set the temperature gradient of the second freezer temperature reduction step down to -30 to -40° C or below to 1° C/min. or below, preferably about 0.5° C/min..

Doing so sets a freezing curve of the rice part of nigiri-sushi such that the temperature gradient in the first freezer temperature reduction step is about 2° C/min., that the temperature gradient in the second freezer temperature reduction step is about 0.5 to 0.3° C/min. or below, and that
the temperature gradient of the third freezing step down to -30°C is about 2°C/min. or below.

With inari-sushi which, unlike nigiri-sushi, has its rice ball enclosed in aburage (or fried sliced tofu) impregnated with boiling juice, the freezing curve is set differently. Specifically, freezing started after preliminarily cooling the freezer and then disposing the sushi in a state of being held in rows in vessels in the freezer as noted before, comprises a first freezer temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature to about -30°C in about 5 to 15 min. with a temperature gradient of about 2°C/min., and a second freezer temperature reduction step of reducing the temperature to -45°C with a temperature gradient of -0.2 to -0.5°C/min..

Thus, the freezing curve that is set for the inari-sushi is such that the temperature gradient in and time of the first freezing step are about 1.2 to 1.5°C/min. and 10 to 20 min., respectively, that the temperature gradient in and time of the second freezing step until passing of the maximum ice generation temperature range are about 0.3°C/min. or below and about 20 to 35 min., respectively, and that the temperature gradient in the third freezing step down to -30°C is about 2°C/min.
Experiment results prove that even when the food which has been frozen by such technical means is thawed under the worst condition of natural thawing, it is possible to minimize the vinegar escapement from boiled rice and changes in the hardness, stickiness, etc. In addition, as for the sushi raw materials such as fish pieces, it is possible to obtain the same character as non-frozen sushi after thawing.

Further, when the vessel top, i.e., top of sushi raw materials, is open, it is suitable to freeze the food in a commonly termed slight air supply space with a minimum of air supplied into the freezer.

Further, as the freezer may be used a batch freezer or a continuous freezer such as a net conveyor, a movable truck or the like.

Aside from sushi, boiled rice or processed food with boiled rice as main component, for instance onigiri, may be frozen in a similar process.

More specifically, boiled rice or the like is disposed in a non-packed or packed state in a freezer, and then freezing is started. The freezing in this case comprises a first freezing step of reducing the temperature of the food from the initial temperature thereof to the freezing point (0 to -4°C), a second freezing step of maintaining a
commonly termed maximum ice generation temperature range from the freezing point to -5 to -10°C, and a third freezing step of reducing the temperature to -20°C or below, preferably -30°C or below, after passing of the maximum ice generation temperature range, the temperature gradient in the first freezing step being set to be greater than the temperature gradient in the second freezing step, the time until passing of the maximum ice generation temperature range of 0 to -10°C of the rice part being set to 15 to 35 min., preferably 15 to 30 min., more preferably 20 to 30 min.

In a specific case of freezing the food at normal temperature, i.e., about 20°C, it is suitable to cause the first freezing step with a temperature gradient of 1.5 to 2.5°C/min., preferably 2°C/min., for 15 to 25 min., preferably about 20 min., cause the second freezing step with a temperature gradient of about 0.5°C/min. or below, preferably 0.3°C/min. or below, to maintain the maximum ice generation temperature range for about 23 to 37 min., preferably about 30 ± 3°C, and cause the third freezing step down to -30°C with a temperature gradient of about 1 to 2.5°C/min., preferably 1.5 to 2°C/min.

Again in this case, if the freezing time of the third freezing step until reaching of -30°C after passing of the maximum ice generation temperature range is too short, the
intended effect can not be attained. Accordingly, it is suitable to set the time to about 10 min. or above, preferably 10 to 20 min.

The freezer temperature will now be described on the basis of freezing curve. A case of freezing boiled rice or the like is taken. In this case, the food is disposed, in a state held in vessels without or after packing, in a freezer, and the freezer is then preliminarily cooled down suitably to about 0 to -10°C, preferably about -5°C. Freezing is then started, and it suitably comprises a first freezer temperature reduction step of reducing the freezer temperature to about -10 to -20°C, preferably about -15°C, in about 10 to 20 min. with a temperature gradient of about 1 to 3°C/min., preferably 1 to 2°C/min., a second freezer temperature reduction step or temperature maintaining step of maintaining a temperature range of about -10 to -20°C, and a third freezer temperature reduction step of reducing the temperature from the temperature in the temperature maintaining step to -30 to -45°C with a substantially linear temperature gradient of 0.5 to 1.5°C/min., preferably 0.5 to 1°C/min, the freezing time of the second step being set to 10 to 23 min., preferably 10 to 20 min., more preferably 15 min..

For such stringent temperature control, a batch
freezer is suitably used as the freezer. However, this is by no means limitative, and it is possible to use as well a net conveyor or other continuous freezers such as those of truck type. In this case, stepwise temperature control is possible by using a continuous freezer with partitioned spaces or rooms on the conveyor belt.

When using a continuous freezer with a belt or net conveyor, along which vessels holding food are moved, it is suitable to preliminarily cool the freezer down to about -10° C and set a freezer temperature reduction step of reducing the temperature from about -10° C down to -40° C with a substantially linear temperature gradient of 0.5° C /min.

A suitable freezing curve of boiled rice or the like was formed in this case such that the temperature of the food was reduced from normal temperature of 23° C to reach a maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 20 min. with a temperature gradient of about 1 to 2° C, that the maximum ice generation temperature range was passed in a subsequent period of about 29 to 38 min. with a slight temperature gradient of 0.3° C/min. or below, preferably about 0.2° C/min., and that the temperature was then reduced to about -28° C in a subsequent period of about 30 to 35 min.
with a temperature gradient of about 0.5 to 1° C/min., preferably 0.7° C/min.

Experiment results prove that even with such technical means it is possible to obtain substantially the same quality as boiled rice before freezing in the hardness, stickiness and taste after thawing under the worst condition of natural thawing.

Further, as described before, in the case where the top of the vessels holding the boiled rice or the like is open, it is suitable to freeze the food in the commonly called slight air supply space with air supplied at a minimum rate into the freezer.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing a freezing characteristic of nigiri-sushi and futomaki in an example of the process according to the invention;

Fig. 2 is a diagram showing a freezing characteristic of inari-sushi in an example of the process according to the invention;

Fig. 3 is a diagram showing a freezing characteristic of inari-sushi and nigiri-sushi in Contrast Example 1 of process (of quick freezing);
Fig. 4 is a diagram showing a freezing characteristic of nigiri-sushi in Contrast Example 2 of process (of slow freezing);

Fig. 5 is a graph showing distributions of measured hardness and stickiness of non-frozen sushi and frozen sushi in the above examples and contrast examples;

Fig. 6 is a perspective view showing a plastic vessel for holding sushi used in an example of the process according to the invention;

Fig. 7 is a flow chart showing a sequence of freezing of boiled rice held in vessel in an example of the process according to the invention;

Fig. 8 is a diagram showing a freezing characteristic of boiled rice in Example 1 of the process according to the invention based on the flow shown in Fig. 7;

Fig. 9 is a diagram showing a freezing characteristic of boiled rice held in vessel in Example 2 of the process according to the invention based on the flow shown in Fig. 7;

Fig. 10 is a diagram showing a freezing characteristic of boiled rice held in vessel in a contrast example (of quick freezing 2) based on the flow shown in Fig. 7;

Fig. 11 is a diagram showing a freezing characteristic of boiled rice held in vessel in a contrast example (of
slow freezing 1) based on the flow shown in Fig. 7;

Fig. 12 is a diagram showing a freezing characteristic of boiled rice held in vessel in a contrast example (of slow freezing 2) based on the flow shown in Fig. 7;

Fig. 13 is a waveform diagram showing a parameter sample obtained by analysis with a textulometer;

Fig. 14 is a diagram showing two-dimensional distributions of measured hardness and stickiness of non-frozen boiled rice and frozen boiled rice shown in Fig. 8;

Fig. 15 is a diagram showing two-dimensional distributions of measured hardness and stickiness of non-frozen boiled rice and frozen boiled rice shown in Fig. 10;

Fig. 16 is a diagram showing two-dimensional distributions of measured hardness and stickiness of non-frozen boiled rice and frozen boiled rice shown in Fig. 12;

Fig. 17 is a table showing results of taste testing of boiled rice samples shown in Figs. 8 to 13 in examples and Contrast Examples 1 and 2;

Fig. 18 is a diagram showing a freezing characteristic of boiled rice in Example 1 of the process according to the invention based on the flow shown in Fig. 7; and

Figs. 19 are photographs showing various sushi to be frozen, with Fig. 19(A) showing nigiri-sushi, Fig. 19(B) showing oshi-sushi, norimaki and futomaki and Fig. 19(C)
showing inari-sushi.

Fig. 20 to Fig. 22 are photographs showing boiled cleaned rice or processed food with boiled rice as main component, with Fig. 20(A) showing boiled cleaned rice, Fig. 20(B) showing sekihan, Fig. 20(C) showing rice cake, Fig. 21 (A) showing onigiri, Fig. 21(B) showing takikomi-gohan, Fig. 21(C) showing chirashi and Fig. 22(A) showing ohagi.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, preferred embodiments of the invention will be described as examples with reference to the accompanying drawings. It is to be construed that unless otherwise specified the temperature reduction conditions, freezing curves, materials, shapes and relative dispositions of the food to be frozen and so forth described hereinunder are by no means limitative but mere examples.

First, 1 wt. part of cleaned rice was boiled with 1.4 wt. parts of cleaned water in a commercially available electric oven. Then, when the rice was cooled down to 40° C, vinegar for boiled rice with vinegar (composed of brewed vinegar, sugar, edible salt, seasonings and amino acid, specifically vinegar for sushi sold by Cupie Shokuhin) was added in an amount of about 10 % of the boiled rice, and the
resultant system was agitated to prepare boiled rice with vinegar at about 25° C.

Then, using this boiled rice with vinegar, nigiri-sushi with ingredients put on rice balls, futomaki and inari-sushi, as shown in Fig. 19, were prepared using well-known sushi-preparing robots at normal temperature. These sushi varieties were each put in a well-known vessel 2 as shown in Fig. 6, made of a packing material of polyethylene, poly-propylene, etc. and open at the top. These vessels holding the sushi were then put on a second and a third shelf of an exclusive food freezing unit (i.e., a batch type air-cooled freezer provided under a trade name "High Power 22" by Maekawa Seisakusho), and then freezing was performed with freezing curves as shown in Figs. 1 to 4.

The batch type freezer "High Power 22" is constructed such that slight air flows through the inside, and it has five shelves disposed one above another.

Fig. 1 shows a freezing characteristic obtained in Example 1 of the process according to the invention with 10 pieces of sushi, i.e., either nigiri-sushi alone or nigiri-sushi and futomaki. As shown in the Figure, the freezer was preliminarily cooled down to about -10° C. Then, freezing was started to reduce the temperature to -30° C in 20 min. with a temperature gradient of 1° C/min., and then the tem-
perature was reduced continually to about -45°C in 40 min. with a linear downward temperature gradient of 0.5°C/min.

With this control characteristic A, a freezing curve of the temperature of the rice ball part of the sushi was produced such that the temperature was reduced from normal temperature, i.e., 20°C, to reach a maximum ice generation temperature range of the neighborhood of -1 to -5°C in an initial period of about 10 to 15 min. from the start of freezing with a temperature gradient of about 1°C/min, then held in the maximum ice generation temperature range for a subsequent period of about 25 min., then reduced to -30°C in a subsequent period of about 10 min. with a temperature gradient of 2.2°C/min. and then reduced to about -42°C in a subsequent period of 15 min. with a temperature gradient of about -1°C/min.

On the basis of the above freezing characteristic, 20 batches of nigiri-sushi, prepared with fish, cuttlefish, shrimp, etc., 20 batches of futomaki and 20 batches of mixed futomaki and nigiri-sushi were frozen repeatedly.

In Example 2, a permanent preservation process at -20°C for 24 hr. was provided after the freezing process. In Example 3, alkali water was used instead of water, and 20 batches of nigiri-sushi 1 was frozen repeatedly.

Fig. 2 shows a freezing characteristic of inari-
sushi in Example 1 of the process according to the invention. As shown in the Figure, first the freezer was preliminarily cooled down to about -10°C, and then freezing of sushi was caused down to -30°C in 10 min. from its start with a temperature gradient of 2°C/min., and then down to about -50°C in a subsequent period of 50 min. with a linearly downward temperature gradient of 0.3°C/min. With the above control characteristic B, a freezing curve of the temperature of inari-sushi was produced such that the temperature was reduced from normal temperature, i.e., 20°C, to reach the maximum ice generation temperature range of the neighborhood of -1 to -5°C in an initial period of about 15 to 20 min. from the start of freezing with a temperature gradient of about 1.3°C/min, then held in the maximum ice generation temperature range for a subsequent period of about 30 min. and then reduced to about -35°C in a subsequent period of 15 to 20 min. with a temperature gradient of 2°C/min.

Again this experiment was carried out repeatedly for 20 batches.

Fig. 3 shows freezing characteristics of mixed inari-sushi and nigiri-sushi 1 in Contrast Example 1 (of quick freezing). As shown in the Figure, as a freezer temperature control characteristic C, the freezer temperature was quickly reduced from normal temperature, i.e., about 20°C, to about
-40° C in about 5 min. with an average temperature gradient of 6° C/min. and then held at -40° C for a period of about 55 min. With this control characteristic C, a freezing curve of the temperature of the rice ball part of the nigiri-sushi I was produced such that with the freezing started from normal temperature of 28° C the temperature was reduced down to -10° C by passing a maximum ice generation temperature range in an initial period of about 5 min. with a temperature gradient of about 4° C/min., then held at that temperature for about 5 min., then reduced to about -40° C in a subsequent period of about 20 to 30 min. and then held at that temperature for a subsequent period of about 30 min..

In the case of inari-sushi, a freezing curve of the temperature of the rice part was produced such that the temperature was reduced from 28° C at the start of freezing to reach the maximum ice generation temperature range of the neighborhood of -1 to -5° C in an initial period of about 7 to 10 min., then held in the maximum ice generation temperature range for a subsequent period of about 10 min., then reduced to about -40° C in a subsequent period of 10 to 20 min. and then held at that temperature for a subsequent period of about 30 min.. Again these freezing experiments are each carried out for 20 batches.

Fig. 4 shows a freezing characteristic nigiri-sushi
in Contrast Example 2 (of slow freezing). As shown in the
Figure, as a freezer temperature control characteristic D,
the freezer temperature was reduced from normal temperature
of about 5° C to about -12° C in 5 min. with a linearly down
ward freezing temperature gradient and then continually
reduced slowly from -12° C to about -30° C in about 80 to 90
min. with an average temperature gradient of 0.2° C/min..

With this control characteristic D a freezing curve of the
temperature of the rice ball part of the sushi was produced
such that the temperature was reduced from the start of
freezing to reach a maximum ice generation temperature range
of the neighborhood of -1 to -5° C in an initial period of
about 25 min., then held in the maximum ice generation tem-
perature range for a subsequent period of about 55 min. and
then reduced to about -25° C in a subsequent period of about
20 to 30 min.. Again this freezing experiment was carried
out for 20 batches.

The frozen sushi which was obtained in the above way,
was covered at the top with a transparent lid and then
sealed gas-tight in a vinylead bag at a temperature of 25° C
and under a reduced pressure of 500 mHg, followed by leaving
at normal temperature for about 120 to 180 min. for thawing.
After-wards, the taste and sense of eating were examined
together with the stickiness and hardness of rice. The
results are shown in Fig. 5.

Referring to Fig. 5, designated at group 10 are characters of non-frozen sushi, at 11 characters of sushi frozen and thawed in Example 1, at 12 characters of sushi frozen and thawed in Example 2, at 13 characters of sushi using rice boiled with alkali water and frozen and thawed in Example 3, at 14 characters of sushi in Contrast Example 1 as a process of quick freezing and thawing, and at 15 characters of sushi frozen in Contrast Example 2 as a process of slow freezing and thawing. The characters of the sushi samples in Examples 1 to 3 are distributed around and not substantially different from the characteristics 10 of the non-frozen sushi. In addition, these sushi samples proved to have good taste and sense of eating when they were actually eaten.

However, the sushi sample with the characters 14 in Contrast Example 1 of quick freezing was high in value of hardness, and its taste and sense of eating were not desirable. The sushi sample with the characters 15 was not good at all when it was actually eaten, due to high value of hardness and low value of stickiness.

It is to be appreciated that according to the invention, even when sushi or onigiri is frozen without freezing in a vinyl packed state for each piece of the food, by
holding plural pieces of the sushi in rows in a vessel, it is possible to obtain substantially the same taste and sense of eating as non-frozen sushi or non-frozen onigiri. This means that the freezing operation can be extremely simplified. In addition, satisfactory quality can be obtained after natural thawing. This means that the frozen food can be directly held on a display table, which is very practical in supermarkets and convenience stores. Further, it is possible to provide sushi processing plants not in the neighborhood of consumption areas but in foreign countries, which is very useful.

Now, a process of freezing and thawing boiled rice will be described with reference to Fig. 7.

First, 600 g of cleaned rice was washed by dipping it in about 1 liter of purified water, then agitating it with the hands 15 times from the left and the same number of times from the right and then removing water. This washing was done 5 times repeatedly. Then, the washed rice was dipped in 840 milliliters of purified water for 120 min. after it was put on the lid with lap.

As soon as the dipping was ended, the rice was boiled and steamed for a total period of 60 min. using a commercially available electric oven.

Then, a sample of the rice was left in a plastic
mesh-like vessel for cooling down to 30° C.

Then, 7 rice packs were each prepared by filling a plastic vessel (15 cm x 11 cm x 3 cm) like that for sushi with 200 g of sample. These rice packs were each preserved.

In the above way, 7 bags x 3 ovens x 6 ovens of packs were prepared.

Then, the packs were disposed on the second shelf of an exclusive food freezing unit (provided with a trade name "Plus α Freezer") manufactured by Maekawa Seisakusho and then frozen such as to produce each of the freezing curves shown in Figs. 8 to 13.

In this experiment, the commercially available "Plus α Freezer" was modified for use into a cassette rack type batch freezer, the inner temperature of which could be reduced down to -50° C, and through which slight air could flow.

After the freezing, each rice pack was packed by air-purged packing in a vinyl bag and then preserved overnight at -20 to -25° C. Then, it was thawed under the bad thawing condition of normal temperature (left alone at 25° C, room temperature) thawing for 180 to 240 min..

After the thawing, analysis with a textulometer (a food physical characteristic measuring instrument manufac-
tured by Zenken Co., Ltd.), water content rate analysis and sensuous taste testing were conducted.

Now, the individual freezing and freezer temperature reduction processes will be described.

Figs. 8 and 9 show a product temperature curve and a freezer temperature curve, respectively, of ideal freezing carried out with the above freezer in an embodiment of the invention. Figs. 10 and 11 are a product temperature curve and a freezer temperature curve, respectively, of quick freezing carried out with the above freezer in a comparative example. Figs. 12 and 13 are product temperature curve and a freezer temperature curve, respectively, of slow freezing carried out with the above freezer in a comparative example.

Of the 7 packs noted above, 6 packs (2 packs as physical property analysis samples, one pack as water content measurement sample, one pack taste testing sample, one pack as temperature measurement sample and one pack as spare (with less than 200 g of rice) were subjected to freezing, while the remaining pack was used as contrast and not subjected to freezing.

The product temperature was measured using "U Logger-L822-T" (manufactured by Unipulse Inc.). More specifically, thermocouple terminals "TCT-G-0,32-2000" (manufactured by Unipulse Inc.) were buried in the four corners and center of
the pack at a depth of about 1 cm from the boiled rice mass
surface such that they were perfectly enclosed in the boiled
rice mass. In this state, the temperature measurement was
carried out. The results are shown in Figs. 8 to 12.

The analysis with the textulometer after the thawing
was carried out by using a textulometer manufactured by
Zenken Co., Ltd.. More specifically, three boiled rice
grains taken out randomly from the sample pack using a pair
of tweezers were held in an analysis cell (or analysis dish),
and an arm was brought into contact with the cell with its
vertical movement. At this time, the boiled rice was squee-
zed by the arm, and an electric resistance that was offered
when the arm was separated was used to calculate the hard-
ness and stickiness.

Particularly with boiled rice, important parameters
are, as shown in Fig. 14, hardness H (first chewing H1,
second chewing H2), stickiness -H (first chewing -H1,
second chewing -H2) and adhesion (A3, A4 (first and second
chewing).

Of the products frozen and thawed on the basis of
the individual freezing curves and non-frozen contrast
product, two-dimensional graphs of the hardness H1 and
stickiness -H1 were formed as shown in Figs. 14 to 16.

As will be understood from these Figures, substanti-
ally the same hardness and stickiness as those of the non-frozen contrast product could be obtained only in the case of freezing on the basis of the ideal curve.

After the thawing, the hardness, stickiness, taste and whiteness were evaluated by 5-mark evaluation on the basis of the standards of the Food Agency, the Ministry of Agriculture and Forestry of Japan. The 5-mark evaluation was made in comparison to the non-frozen contrast product (mark 5 representing the highest evaluation). The results are shown in Fig. 17.

As is obvious from the Figure showing evaluation examples, the taste and other characters of the products frozen and thawed on the basis of the ideal curve are good even when the products are thawed under the worst condition of natural thawing (at room temperature of 20 to 25°C), that is, thawed at the gelatinization temperature of starch or below.

Besides, even when the products are left at room temperature of 20°C for more than 7 hr. after the thawing, the taste deterioration is substantially the same as that of the non-frozen boiled rice or sushi and gives rise to no problem.

Further, in the case of quick thermal thawing at a temperature above the α / β transition point of starch
with an electronic oven, hot air, hot water, etc. under good conditions, the taste can not be distinguished from that of rice which has just been boiled.

Further, since it is possible to maintain sufficient quality when the product is thawed by natural thawing, fluctuations of the thawing conditions on the shop side give rise to no problem.

The freezing processes shown in Figs. 8 to 12 will now be described in detail.

In the case of Fig. 8, the freezer was first preliminarily cooled down to about -5° C, and then the temperature was reduced to about -15° C in 7 min. with a temperature gradient of 1.5° C/min., then held at the temperature of -15° C for 15 min. and then continually reduced to about -42° C in 40 min. with a linear downward freezing temperature gradient of 0.7 to 0.8° C/min.. With this control characteristic E, a freezing curve of the temperature of boiled rice was produced such that the temperature was reduced from normal temperature of 22° C to reach a maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 20 to 28 min with a temperature gradient of about 1.3° C, then held in the maximum ice generation temperature range for a subsequent period of about 25 to 30 min. and then reduced to about -25° C in a
subsequent period of about 10 to 15 min. with a temperature gradient of about 1.6° C/min.

In the case of Fig. 9, the freezer was first preliminarily cooled down to about -5° C, and then the temperature was reduced to about -15° C in 7 min. with a temperature gradient of 1.2 to 1.5° C/min., then held at -15° C for 15 min. and then continually reduced to about -42° C in 40 min. with a linearly downward freezing temperature gradient of 0.7 to 0.8° C/min. With this control characteristic F, a freezing curve of the temperature of boiled rice was produced such that the temperature was reduced from normal temperature of 20° C to reach the maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 20 to 25 min. with a temperature gradient of about 1.2° C, then held in the maximum ice generation temperature range for a subsequent period of about 20 to 25 min. and then reduced to about -20 to -25° C in a subsequent period of 12 to 17 min. with a temperature gradient of about 1.5° C/min.

Fig. 10 shows a freezing characteristic in another contrast example (of quick freezing 2). In this case, the freezer was first preliminarily cooled down to about -37° C, and then the temperature was gradually reduced to about -50° C. With this control characteristic H, the temperature
of boiled rice was reduced from normal temperature of 20° C to reach the maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 7 min. with a temperature gradient of about 2° C, then passed the maximum ice generation temperature range from 0 ~ -3° C to -4 ~ -10° C in a subsequent period of about 10 to 15 min. with a temperature gradient of 0.3° C, then reduced to -30° C in a subsequent period of about 8 min. with a temperature gradient of about 3° C/min. and then gradually converged to -50° C.

Fig. 11 shows a freezing characteristic in a further contrast example (of slow freezing 1). In this case, the freezer was first preliminarily cooled down to about -2° C, and then the temperature was reduced to about -7° C in 3 min. with a temperature gradient of 2° C/min., then gradually reduced from -7° C to 13° C in 55 min. with a temperature gradient of about 0.1° C, and then reduced continually to about -30° C in 40 min. with a linearly downward freezing temperature of 0.4 to 0.5° C/min.. With this control characteristic, a freezing curve of the temperature of boiled rice was produced such that the temperature was reduced from normal temperature of 20° C to reach the maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 20 to 25 min. with a temperature...
gradient of $1.2^\circ$ C/min., then held in the maximum ice generation temperature range in a subsequent period of 35 to 45 min. and then reduced to about -20 to -25$^\circ$ C in a subsequent period of about 30 min. with a temperature gradient of about 0.7$^\circ$ C/min..

Fig. 13 shows a freezing characteristic of another contrast example (slow freezing 2) based on the flow shown in Fig. 7. In this case, the freezer was first preliminarily cooled down to about -8$^\circ$ C, and then the temperature was reduced to about -18$^\circ$ C in 8 min. with a temperature gradient of 1.2$^\circ$ C/min., then held at the temperature of -18$^\circ$ C for 24 min., then gradually reduced to -28$^\circ$ C in 30 min. with a temperature gradient of about 0.3$^\circ$ C/min., and then held at the temperature of -28$^\circ$ C for 28 min.. With this control characteristic J, a freezing curve of the temperature of boiled rice was produced such that the temperature was reduced from normal temperature of 23$^\circ$ C to the maximum ice generation temperature range of the neighborhood of 0 to -3$^\circ$ C in an initial period of about 20 min. with a temperature gradient of 1.2$^\circ$ C, then reduced to pass the maximum ice generation temperature range of in a subsequent period of about 38 min. with a slight temperature gradient of 0.2$^\circ$ C/min. and then reduced to about -28$^\circ$ C in a subsequent period of about 30 to 35 min. with a temperature gradient of
about 0.7°C/min.

In the case of Fig. 8 concerning an example of the invention, it is necessary to produce a freezer temperature curve, which takes about 8 min. for the first freezer temperature reduction step to reduce the freezer temperature down to about -15°C, and about 15 min. for the second freezer temperature reduction step to maintain the temperature of about -15°C, and about 35 to 40 min. for the third freezer temperature reduction step to reduce the freezer temperature to -42°C with a substantially linear temperature gradient.

In the case of Fig. 9, it is necessary to produce a freezer temperature curve, which takes about 4 min. for the first freezer temperature reduction step to reduce the freezer temperature to about -8 to -10°C, and 15 to 17 min. for the second freezer temperature reduction step to reduce the freezer temperature gradually from about -8°C to -15°C, and about 40 to 45 min. for the third freezer temperature reduction step to reduce the freezer temperature to about -37°C with a substantially linear temperature gradient.

However, changing the freezer temperature in relation to time is unsuitable for continuous freezers, in which vessels are moved with conveyor trucks or pallets moved on a belt conveyor, although there is no problem in the case of batch processing.
In continuous freezing carried out by moving vessels on a net conveyor, as shown in Fig. 19, subsequent to cooling the freezer to about -10° C, a freezer temperature reduction step is provided such as to reduce the temperature from about -10° C to -40° C with a substantially linear temperature gradient of 0.5° C/min.

With this control characteristic K, a freezing curve of the temperature of boiled rice was produced such that the temperature was reduced from normal temperature of 23° C to reach a maximum ice generation temperature range of the neighborhood of 0 to -3° C in an initial period of about 20 min. with a temperature gradient of about 1.2° C/min., then caused to pass the maximum ice generation temperature range in a subsequent period of 38 min. with a slight temperature gradient of about 0.2 to 0.5° C/min and then reduced to about -28° C in a subsequent period of about 30 to 35 min. with a temperature gradient of about 0.5 to 1° C/min., preferably 0.7° C/min..

While the invention has been described in connection with boiled rice alone, it will be readily understood that substantially the same taste and sense of eating as those of non-frozen boiled rice are obtainable with processed food with boiled rice as main component, such as onigiri, chirashi, etc.. Further, while boiled rice, curry rice, okowa, etc.
which are to be eaten in a hot state may be thawed using an electronic oven, but chirashi, onigiri, etc. which are to be eaten in a cold state may be thawed without use of any electronic range or the like but by natural thawing to obtain substantially the same taste and sense of eating as those of non-frozen food. Thus, the invention is very beneficial.

It is to be appreciated that according to the invention it is only necessary to preserve, for instance, a large amount of factory-boiled rice by freezing in a state of being packed in vessels or processed into sushi or the like for providing tasteful boiled rice, onigiri, sushi, etc. when desired and in necessary amounts. Thus, there is no need of a 24-hour rice boiling system, and it is possible to improve inefficient production of small amounts of various kinds of food. Further, since the food can be preserved, it is possible to eliminate loss by discarding, even when the consumption is low.

Further, plants for processing boiled rice into processed food products, may not be installed near consumption areas but be installed in foreign countries. Thus, the invention is very beneficial.
What is claimed is

1. A process of freezing sushi, such as nigiri-sushi, inari-sushi, maki-sushi, etc., comprising disposing the sushi, in a state held either alone or mixed in vessels, in a freezer, and then starting freezing, the freezing comprising a first freezing step of reducing the temperature of the rice ball part of the sushi from the initial temperature at the start of freezing to the freezing point (0 to -4° C), a second freezing step of reducing the temperature until passing of a maximum ice generation temperature range from the freezing point to -10° C while maintaining the same range for a predetermined period of time, and a third freezing step of reducing temperature to -15° C or below, preferably -20° C or below, more preferably -30° C or below, after the passing of the maximum ice generation temperature range, the temperature gradient in said first freezing step being set to be greater than the temperature gradient in said second temperature gradient, the time of said second freezing step being set to be longer than the time of said first freezing step.

2. The process of freezing sushi according to claim 1, wherein the time of said second freezing step is set to about 15 to 35 min.
3. The process of freezing sushi according to claim 1, wherein the temperature gradient in said third freezing step from -20 to -30°C after the passing of the maximum ice generation temperature range is set to be substantially equal to or greater than the temperature gradient in said first freezing step.

4. The process of freezing sushi according to claim 1, wherein the temperature gradient in said first freezing step is set to about 1 to 2.5°C/min., preferably about 1 to 2°C/min., the temperature gradient in said second freezing step is set to about 0.5°C/min. or below, preferably 0.3°C/min. or below, and the temperature gradient in said third freezing step is set to about 1 to 3°C/min., preferably about 1.5 to 2.5°C/min.

5. The process of freezing sushi according to claim 1, wherein the freezing time in said third freezing step until reaching of -30°C is set to about 10 min. or above, preferably about 10 to 20 min.

6. The process of freezing sushi according to claim 1, wherein nigiri-sushi, inari-zushi, maki-sushi or the like is disposed with a plurality of sushi pieces held in rows in ea
ch vessel in the freezer, and then the freezer is preliminarily cooled down to about 0 to -15° C, preferably -5 to -10° C, then freezing being started, the freezing comprising a first temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature to about -30° C in about 5 to 25 min. from the art of freezing of sushi, and a subsequent second temperature reduction step of reducing the freezer temperature to a lower temperature, the temperature gradient in the first temperature reduction step being set to be greater than the temperature gradient in the second temperature reduction step, the time until passing of the maximum ice generation temperature range of 0 to -10° C of rice part of the sushi being set to 15 to 35 min., preferably 15 to 25 min..

7. The process of freezing sushi according to claim 6, wherein the temperature gradient in the second temperature reduction step is set to 1° C/min. or below, preferably about 0.2 to 0.5° C/min..

8. The process of freezing sushi according to claim 6, wherein nigiri-sushi or maki-sushi is frozen, and after preliminarily cooling down the freezer to the afore-said
preliminary cooling temperature, the sushi is disposed in a state held in rows in vessels in the freezer, freezing then being started, the freezing comprising a first temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature to about -30°C in about 15 to 25 min., and a subsequent second temperature-reduction step of reducing the freezer temperature to a lower temperature, the temperature gradient in the first temperature reduction step being set to be greater than the temperature gradient in the second temperature reduction step, the time until passing (or of maintenance) of the maximum ice generation temperature range of 0 to -10°C, more specifically -3 to -6°C, of rice part of the sushi being set to 15 to 25 min, preferably 15 to 20 min.

9. The process of freezing sushi according to claim 6, wherein nigiri-sushi or maki-sushi at normal temperature is frozen, the temperature gradient in and time of the first temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature of -10°C to -30°C are set to about 1 to 2°C/min. and about 20 min, respectively, and the temperature gradient in the second temperature reduction step of reducing the freezer temperature to -30 to -40°C or below is set to 1°C/min. or below,
preferably about 0.5° C/min..

10. The process of freezing sushi according to claim 6, wherein the freezing curve of the nigiri-sushi rice ball part or the maki-sushi is set such that the temperature gradient in the first freezing step is about 2° C/min., the temperature gradient in the second freezing step is about 0.5 to 0.3° C/min. or below, and the temperature gradient in the third freezing step down to -30° C is about 2° C or below.

11. The process of freezing sushi according to claim 1, wherein inari-sushi is frozen, and after preliminarily cooling the freezer to the afore-said preliminary cooling temperature, the sushi is disposed in a state held in rows in vessels in the freezer, freezing then being started, the freezing comprising a first temperature reduction step of reducing the freezer temperature from the preliminary cooling temperature to about -30° C in about 5 to 15 min. with a temperature gradient of about 2° C/min., and a second temperature reduction step of reducing the freezer temperature down to -45° C with a temperature gradient of -0.2 to -0.5° C/min.
12. The process of freezing sushi according to claim 1, wherein inari-sushi is frozen according to a freezing curve such that the temperature gradient in and time of the first freezing step are about 1.2 to 1.5°C/min. and 10 to 20 min., respectively, the temperature gradient in and time of the second freezing step until passing of the maximum ice generation temperature range are about 0.3°C/min. or below and about 25 to 35 min., respectively, and the temperature gradient in the third freezing step down to -30°C is about 2°C/min..

13. A process of freezing boiled rice or processed food with boiled rice as main component, the boiled rice or the like, comprising disposing the food, either as such or in a suitably enclosed state in a freezer, and then starting freezing, the freezing comprising a first freezing step of reducing the freezer temperature from the initial temperature at the start of freezing to the freezing point (0 to -4°C) of the boiled rice, a second freezing step of maintaining a maximum ice generation temperature range from the freezing point to -4 to -10°C, and a third freezing step of reducing the freezer temperature to -20°C, preferably -30°C or below, after passing of the maximum ice generation temperature range, the temperature gr
adjacent in the first freezing step being set to be greater than the temperature gradient in the second freezing step, the time until passing of the maximum ice generation temperature range from 0 to -10°C of the boiled rice part being set to 15 to 35 min., preferably 15 to 30 min., more preferably 20 to 30 min..

14. The process of freezing cooked rice or the like according to claim 13, wherein the boiled rice or processed food with boiled rice as main component is frozen from normal temperature, the temperature gradient in and time of the first freezing step are set to 1.5 to 2.5°C/min., preferably 2°C/min., and 15 to 25 min., preferably about 20 min., respectively, the temperature gradient in the second freezing step are set to about 0.5°C/min. or below, preferably 0.3°C/min. or below, to maintain the maximum ice generation temperature range, preferably about 30°C ± 3°C, for about 23 to 37 min., respectively, and the temperature gradient in the third freezing step of reducing the freezer temperature from -20°C to -30°C is set to about 1 to 2.5°C/min, preferably 1.5 to 2°C.

15. The process of freezing boiled rice or the like according to claim 13, wherein the freezing time in the
third freezing step until reaching of -30°C after passing of
the maximum ice generation temperature range is set to about
10 min. or above, preferably 10 to 20 min..

16. A process of freezing boiled rice or the like
disposed in a state held as such or suitably wrapped in
vessels in a freezer, the freezer being preliminarily cooled
down in this state to about 0 to -10° C, preferably
about -5° C, freezing then being started, the freezing
comprising a first step of reducing the freezer temperature
with a temperature gradient of about 1 to 3° C/min.,
preferably 1 to 2° C/min., for about 10 to 20 min. to about
-10 to -20° C, preferably about -15° C, a second step of
maintaining a temperature range of about -10 to -20° C,
and a third step of reducing the freezer temperature from the
temperature in the temperature maintaining step with a substantially linear temperature gradient of 0.5 to 1.5° C/min.,
preferably 0.5 to 1° C/min., to -30 to -45° C, the freezing
time of the second step of freezing being set to
10 to 23 min., preferably 10 to 20 min., more preferably
15 min..

17. A process of freezing boiled rice or processed
food with boiled rice as main component by moving vessels ho
lding the boiled rice or the like on a conveyor in a continuous freezer, wherein:

the freezer is preliminarily cooled down to about -10° C, freezing then being started, the freezing comprising a step of reducing the freezer temperature about from -10° C to -40° C with a substantially linear temperature gradient of 0.5° C/min.

18. A process of freezing boiled rice or processed food with boiled rice as main component by moving vessels holding the boiled rice or the like on a conveyor in a continuous freezer, wherein:

the boiled rice or the like is frozen according to a freezing curve such that after reaching of a maximum ice generation temperature range of the neighborhood of 0 to -3° C from normal temperature with a temperature gradient of 1 to 2° C, the temperature of the food is reduced with a slight temperature gradient of 0.3° C/min. or below, preferably about 0.2° C/min. until passing of the maximum ice generation temperature range, and then reduced to -20 to -30° C with a temperature gradient of about 0.5 to 1° C/min., preferably 0.7° C/min.
FIG. 4

Temperature (°C)

Freezer interior temperature

Edomae-sushi

Time (min.)
FIG. 7

Weighing cleaned rice...600g

Washing rice... (15 times left and right per about one liter of purified water) × 5 times

- Measuring water temperature
- Adding 840ml of purified water

Dipping...120 min.

- Measuring water temperature when dipping

Rice cooking with boiled...60 min. after turning on switch

- Measuring rice cooking finished temperature

Leaving to cool, cooling... about 30°C

Packing...200g each, 7 packs in total

(• as Physical property analysis sample: 2 packs
• as Water content measurement sample: 1 pack
• as Taste testing sample: 1 pack
• as Temperature curve data sample: 1 pack
• as Cont. sample: 1 pack
• as Spare (less than 200g): 1 pack)

Freezing... { Quick freezing : 60 min. }<Cont. sample(non-freezing)>
{ Ideal freezing : 60 min. }
{ Slow freezing : 90 min. } Analyzing(texture, water content rate)

Air purged packaging (packaging)

Preserving... -20〜-25°C, for one night

Thawing (normal temperature thawing)... room temperature, 180〜240 min.

Analyzing (texture, water content rate)

Taste sensuous testing
FIG. 8

[Diagram showing temperature vs. time for-cooked rice freezing test and ideal freezing 1. The x-axis represents temperature (°C) ranging from -50 to 30, and the y-axis represents time (min.) ranging from 0 to 60. The graph shows two curves: one for the cooked rice freezing test and the other for the ideal freezing 1. The center of the freezer interior is indicated.]
FIG. 9

Cooked cleaned rice freezing Example 2

Temperature

0 10 20 30 40 50 60 min

Time
Cooked cleaned rice freezing test
Textulogram

Non-frozen product + Slow frozen product
### FIG. 17

<table>
<thead>
<tr>
<th>Process</th>
<th>Sample(Oven)</th>
<th>Hardness</th>
<th>Stickiness</th>
<th>Taste</th>
<th>Whiteness</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cont.</td>
<td>Q (Quick freezing)</td>
<td>1  2  3  4  5</td>
<td>2  3  4  5  5</td>
<td>2  3  2  3  2</td>
<td>2  3  1  2  3</td>
<td>2  3  2  3  3</td>
</tr>
<tr>
<td></td>
<td>S (Slow freezing)</td>
<td>1  2  2  2  2</td>
<td>2  3  3  3  3</td>
<td>2  3  2  2  2</td>
<td>2  3  2  3  3</td>
<td>2  3  3  3  3</td>
</tr>
<tr>
<td></td>
<td>B (Ideal freezing)</td>
<td>1  2  3  4  5</td>
<td>2  3  3  4  5</td>
<td>2  3  2  3  4</td>
<td>2  3  3  4  5</td>
<td>2  3  3  4  5</td>
</tr>
</tbody>
</table>

Results of taste sensorus tests
FIG. 18

Cooked cleaned rice freezing curve

Temperature (°C)

Time (min.)

-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60

20°C 30°C 40°C 50°C 60°C

10 min. (8~10)

2.5 min. (20~30)

1 min. (15~20)

-2°C

-4°C

-6°C
A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A23L3/36 A23B9/10

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)
IPC 6 A23L A23B

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>
| X        | PATENT ABSTRACTS OF JAPAN
          | vol. 6, no. 63 (C-099) 22 April 1982 & JP,A,57 005 659 (KAWASAKI HEAVY IND LTD)
          | 12 January 1982 see abstract                                                   | 1-18                  |
| X        | PATENT ABSTRACTS OF JAPAN
          | vol. 12, no. 333 (C-526) 8 September 1988 & JP,A,63 094 945 (TOOKATSU FOOD IND)
          | 26 April 1988 see abstract                                                      | 1-18                  |
| X        | PATENT ABSTRACTS OF JAPAN
          | vol. 6, no. 31 (C-092) 24 February 1982 & JP,A,56 151 470 (KAWASAKI HEAVY IND LTD)
          | 24 November 1981 see abstract                                                   | 1-18                  |

Further documents are listed in the continuation of box C.

Patent family members are listed in 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 document but published on or after the international filing date
  * L' document which may throw doubts on priority claim(s) or which is used to establish the publication date of another citation or other special reason (as specified)
  * 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.

* A & document member of the same patent family

Date of the actual completion of the international search
16 December 1994

Date of mailing of the international search report
25.11.94

Name and mailing address of the ISA
European Patent Office, P.B. 3818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel: (+31-70) 340-8011, Tx: 31 651 epo nl
Fax: (+31-70) 340-3016

Authorized officer
Bend1, E
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>PATENT ABSTRACTS OF JAPAN vol. 7, no. 281 (C-200) 15 December 1983 &amp; JP,A,58 158 146 (MIZUNO ROKI KOGYO KK) 20 September 1983 see abstract ---</td>
<td>1-18</td>
</tr>
<tr>
<td>A</td>
<td>EP,A,0 051 191 (MITSUDA HISATERU) 12 May 1982 -----</td>
<td></td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP-A- 57071383</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP-B- 59022509</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA-A- 1162098</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US-A- 4396636</td>
</tr>
</tbody>
</table>