

DESCRIPTION

Title of Invention

HIGH-IRON-CONTENT YEAST EXTRACT, METHOD FOR PRODUCING SAME,
AND FOOD PRODUCT

5

Technical Field

The present invention relates to an iron-rich yeast extract and a method for producing the extract, and food containing the extract.

10 Background Art

Iron is a constituent component of hemoglobin and various enzymes, and its deficiency is known to cause anemia and deterioration in motor function, cognitive function, and the like. Additionally, loss of iron as menstrual blood and increase in demand for it during pregnancy have large impacts to its required amount (see NPL
15 1). Therefore, there is a need to develop a safe food material which allows for efficient ingestion and absorption of iron into a body and which can improve anemia and deterioration in motor function and cognitive function associated with iron deficiency.

Yeast has been utilized as a food material by human since a long time ago.
20 For example, there has been proposed a technology for allowing yeast to contain iron in a high concentration (e.g., see PTL 1). Therefore, yeast into which iron has been uptaken or extract thereof is thought to be available as a safe iron-enriched food material.

Although conventional iron-containing yeast can be used as a food material,
25 there has been a demand for further reducing its non-food odors such as a metallic odor and an unpleasant odor, and its non-food tastes such as a metallic taste, an off-taste, and a harsh taste. The conventional iron-containing yeast is water-

insoluble, so that turbidity and precipitation are caused when it is added to food. As a result, the conventional iron-containing yeast cannot be used in, especially, a soft drink, which is problematic.

Preparation of an extract from mineral-containing yeast (e.g., iron-containing yeast) has been performed by, for example, the following methods: (1) a hot-water extraction method, (2) an autolysis method, and (3) an enzymolysis method (e.g., see NPL 2).

However, the methods of (1) to (3) have a problem of a low mineral recovery rate (extraction rate). The methods of (2) and (3) have a problem that a yeast odor and a yeast taste which are distinctive of a yeast extract remain in the resultant extract. The method of (3) has problems of a high cost and a residual enzyme in the resultant extract.

Therefore, there has been a keen demand for rapid development of an iron-rich yeast extract which contains iron derived from a natural product in a high concentration, which is excellent in water-solubility, which is sufficiently reduced in non-food odors and non-food tastes, which does not impair appearance of food containing it, and which does not impair a flavor of food containing it; a method for producing the extract; and food containing the extract.

Citation List

Non-Patent Literature

NPL 1: "Dietary Reference Intakes for Japanese 2010," Ministry of Health, Labour and Welfare, the report from the Scientific Committee of "Dietary Reference Intakes for Japanese", published by DAI-ICHI SHUPPAN Co. Ltd., p. 218 – p. 226, XLVIII (2010)

NPL 2: Hiroshi Sugimoto, "Transition of yeast extract production method (I) -from the trend of patent applications in Japan-," New Food Industry 1994, Vol.

36, No. 10, p. 41 – 48

Patent Literature

PTL 1: Japanese Patent Application Laid-Open (JP-A) No. 08-332083

5 Summary of Invention

Technical Problem

The present invention aims to meet the demand, break the status quo, solve the existing problems, and achieve the following object. That is, an object of the invention is to provide an iron-rich yeast extract which contains iron derived from a
10 natural product in a high concentration, which is excellent in water-solubility, which is sufficiently reduced in non-food odors and non-food tastes, which does not impair appearance of food containing it, and which does not impair a flavor of food containing it; a method for producing the extract; and food containing the extract.

15 Solution to Problem

Means for solving the problems are as follows.

<1> A method for producing an iron-rich yeast extract, comprising:

extracting the iron-rich yeast extract by suspending iron-containing yeast in a solution containing a carboxylic acid, a carboxylate, or both thereof to thereby
20 obtain a suspension, and separating the suspension into a solid component and a liquid component.

<2> The method according to <1>, wherein the carboxylic acid is a monovalent to trivalent carboxylic acid, and wherein the carboxylate is a monovalent to trivalent carboxylate.

25 <3> The method according to <1> or <2>, wherein the carboxylic acid is a trivalent carboxylic acid, and wherein the carboxylate is a trivalent carboxylate.

<4> The method according to any one of <1> to <3>, wherein the carboxylic acid

is citric acid, and wherein the carboxylate is trisodium citrate.

<5> The method according to any one of <1> to <4>, wherein a temperature of the suspension during the extracting is in the range of 30°C to 100°C.

<6> The method according to any one of <1> to <5>, wherein a pH value of the suspension during the extracting is in the range of 4.0 to 9.5.

<7> The method according to any one of <1> to <6>, wherein a total amount of the carboxylic acid and the carboxylate is in the range of 2.0 mol to 17.0 mol relative to 1 mol of iron contained in the yeast.

<8> The method according to any one of <1> to <7>, further comprising, prior to the extracting, hot-water treating the yeast by suspending the yeast in hot-water of 60°C to 120°C to thereby obtain a suspension, and separating the suspension into a solid component and a liquid component.

<9> The method according to <8>, wherein, in the hot-water treating, a phosphoric acid salt is added to the hot-water.

<10> An iron-rich yeast extract, comprising:

0.2% by mass or more of iron derived from yeast,

wherein a turbidity is 0.1 or less in terms of absorbance at a wavelength of 660 nm (O. D. 660) when 1 g of the iron-rich yeast extract is dissolved or dispersed into 100 mL of water.

<11> The iron-rich yeast extract according to <10> produced by the method for producing an iron-rich yeast extract according to any one of <1> to <9>.

<12> The iron-rich yeast extract according to <10> or <11>, wherein the yeast is edible yeast.

<13> The iron-rich yeast extract according to <12>, wherein the edible yeast is at least one selected from the group consisting of baker's yeast, brewer's yeast, wine yeast, sake yeast, and miso or soy sauce yeast.

<14> The iron-rich yeast extract according to <12>, wherein the edible yeast is

Saccharomyces cerevisiae.

<15> The iron-rich yeast extract according to any one of <10> to <14>, wherein the iron-rich yeast extract is added to food.

<16> The iron-rich yeast extract according to <15>, wherein the food is a fluid diet or a soft drink.

<17> Food, comprising:

the iron-rich yeast extract according to any one of <10> to <16>.

Advantageous Effects of Invention

The present invention can solve the existing problems, and can provide an iron-rich yeast extract which contains iron derived from a natural product in a high concentration, which is excellent in water-solubility, which is sufficiently reduced in non-food odors and non-food tastes, which does not impair appearance of food containing it, and which does not impair a flavor of food containing it; a method for producing the extract; and food containing the extract.

Brief Description of Drawings

FIG. 1 is a graph illustrating iron-extraction rates with pure water, sodium chloride, and each carboxylate in Test Example 1.

FIG. 2 is a graph illustrating iron-extraction rates with each carboxylate in Test Example 2.

FIG. 3 is a graph illustrating an effect of temperature of a suspension on an iron-extraction rate in Test Example 3.

FIG. 4 is a graph illustrating an influence of pH of a suspension on an iron-extraction rate in Test Example 4.

FIG. 5 illustrates a relationship between a concentration of trisodium citrate in aqueous solution and an iron-extraction rate in Test Example 5.

FIG. 6A is one exemplary photograph illustrating water-solubilities of an iron-rich yeast extract powder, which is one aspect of the present invention, and MINERAL YEAST Fe in Test Example 6.

FIG. 6B is a photograph of aqueous solutions in FIG. 6A after centrifugation at 3,000 rpm for 5 min.

FIG. 6C is one exemplary photograph illustrating solubilities into an apple juice solution of an iron-rich yeast extract powder, which is one aspect of the present invention, and MINERAL YEAST Fe in Test Example 6.

FIG. 6D is a photograph of apple juice solutions in FIG. 6C after centrifugation at 3,000 rpm for 5 min.

Description of Embodiments

(Production method of iron-rich yeast extract)

A method for producing an iron-rich yeast extract of the present invention comprises an extraction step; and, if necessary, further comprises other steps such as a hot-water treatment step and a drying step.

<Extraction step>

The extraction step comprises suspending iron-containing yeast in a solution containing a carboxylic acid, a carboxylate, or both thereof to thereby obtain a suspension, and separating the suspension into a solid component and a liquid component. The extraction step results in an iron-rich liquid component (extract).

<<Yeast>>

The yeast is not particularly limited and may be appropriately selected depending on the purpose, as long as it contains iron in its body. An iron content in the yeast is preferably high as possible in the case where the iron-rich yeast extract is used as an iron-enriched food material. However, from the viewpoints of limitation of an amount of iron uptaken by the yeast and of an efficient production

of the iron-rich yeast extract, the iron content is preferably 0.01% by mass to 5% by mass, more preferably 1% by mass to 5% by mass, relative to dry mass of the yeast.

The iron content in the yeast, as used herein, refers to an amount of iron contained in a yeast body. For example, the iron content is preferably kept at a high level even after washing, for example, in the case where the yeast is washed with water. In such yeast, iron is not removed and remains within the body even after washing, so that the iron is derived from the body and is highly safe.

Therefore, in the case where the hot-water treatment (washing) is performed for reducing an odor and a taste which are distinctive of yeast, the yeast extract does not impair a taste of food containing it, and contains the iron in a high concentration. As a result, the yeast extract is suitable as a food material.

The iron content in the yeast can be measured by known methods such as an atomic absorption spectrometry or an ICP emission spectrometric analysis.

The iron-containing yeast may be produced by culturing yeast in an iron-containing culture solution to thereby allow iron to be uptaken into the yeast, or by slowly stirring and/or shaking yeast in a suspended state in a solution containing iron an an amount of 2,000 ppm by mass or more (e.g., see JP-A No. 08-332083); or may be a commercially available product. Examples of the commercially available product include MINERAL YEAST Fe (Oriental Yeast Co., Ltd.). An amount of iron to be added to the culture medium is not particularly limited and may be appropriately selected depending on the purpose, but it preferably achieves both of a high iron utilization rate (uptake rate of iron into yeast) and a high yield based on sugar (growth rate).

A type of iron to be added, a type of a culture medium, and a culturing condition are not particularly limited and may be appropriately selected depending on the purpose.

A form of the iron-containing yeast is not particularly limited and may be

appropriately selected depending on the purpose. For example, the iron-containing yeast may be in the form of a wet mass or powder.

The yeast may further contain minerals other than iron. The minerals are not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include manganese, copper, magnesium and zinc. These minerals may be contained alone or in combination in the yeast. These minerals are, in general, preferably contained in a high concentration, but the concentration varies depending on the purpose and cannot be unambiguously defined.

The yeast is particularly preferably edible yeast in the case where extract thereof is used as a food material.

The edible yeast is not particularly limited and may be selected from those known in the art. Examples thereof include baker's yeast, brewer's yeast, wine yeast, sake yeast, and miso or soy sauce yeast. Among them, the baker's yeast is particularly preferable.

The edible yeast is not particularly limited and may be selected from those known in the art. Examples thereof include Saccharomyces spp., Torulopsis spp., Mycotorula spp., Torulaspora spp., Candida spp., Rhodotorula spp., and Pichia spp.

Specific examples of the edible yeast include Saccharomyces cerevisiae, Saccharomyces carlsbergensis, Saccharomyces uvarum, Saccharomyces rouxii, Torulopsis utilis, Torulopsis candida, Mycotorula japonica, Mycotorula lipolytica, Torulaspora delbrueckii, Torulaspora fermentati, Candida sake, Candida tropicalis, Candida utilis, Hansenula anomala, Hansenula suaveolens, Saccharomycopsis fibligera, Saccharomyces lipolytica, Rhodotorula rubra, and Pichia farinosa.

Among them, preferable are Saccharomyces cerevisiae, and Saccharomyces carlsbergensis, particularly preferable is Saccharomyces cerevisiae.

<<Carboxylic acid and carboxylate>>

The carboxylic acid is not particularly limited and may be appropriately selected depending on the purpose. However, from the viewpoint of an iron-extraction rate (iron-elution rate), a monovalent to trivalent carboxylic acid is preferable, and a trivalent carboxylic acid is more preferable.

5 Examples of the monovalent carboxylic acid include formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pyruvic acid, and gluconic acid.

 Examples of the bivalent carboxylic acid include oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, fumaric acid, maleic acid, tartaric acid,
10 oxaloacetic acid, and α -ketoglutaric acid.

 Examples of the trivalent carboxylic acid include citric acid, isocitric acid, aconitic acid, and oxalosuccinic acid.

 Among them, from the viewpoints of addition to food and an iron-extraction rate, acetic acid, gluconic acid, tartaric acid, succinic acid, and citric acid are
15 preferable, and citric acid is more preferable.

 The carboxylic acid may be used alone or in combination.

 The carboxylate is not particularly limited and may be appropriately selected depending on the purpose. However, from the viewpoints of an iron-extraction rate (iron-elution rate), a monovalent to trivalent carboxylate is
20 preferable, and a trivalent carboxylate is more preferable.

 Examples of the carboxylate include salts of the above-described specific carboxylic acids.

 Among them, from the viewpoints of addition to food and an iron-extraction rate, an acetate, a gluconate, and a tartrate, a succinate, and a citrate are
25 preferable, and a citrate is more preferable. As the citrate, trisodium citrate is one suitable example.

 The carboxylate may be used alone or in combination.

A type of the salt is not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include salts of alkali metals such as sodium and potassium; and salts of alkaline earth metals such as magnesium and calcium. These may be used alone or in combination.

5 Either of the carboxylic acid or the carboxylate may be used. Alternatively, both of the carboxylic acid and the carboxylate may be used.

An amount of the carboxylic acid or the carboxylate is not particularly limited and may be appropriately selected depending on the purpose. However, relative to 1 mol of iron contained in the yeast, the total amount of the carboxylic
10 acid and the carboxylate is preferably in the range of 2.0 mol to 17.0 mol, more preferably in the range of 2.0 mol to 15.0 mol, particularly preferably in the range of 2.5 mol to 11.0 mol, from the viewpoint of an iron-extraction rate.

A solvent used for a solution containing the carboxylic acid, the carboxylate, or both thereof (hereinafter may be referred to as “carboxylic buffer”) is not
15 particularly limited and may be appropriately selected depending on the purpose. The solvent is typically water, and may be a mixed solution of the water and an organic solvent (e.g., alcohol).

A concentration of the carboxylic buffer is not particularly limited and may be appropriately selected depending on the purpose, but is preferably 70 mmol/L to
20 700 mmol/L, more preferably 80 mmol/L to 500 mmol/L, particularly preferably 90 mmol/L to 450 mmol/L, from the viewpoint of an iron-extraction rate.

The pH value of the carboxylic buffer is not particularly limited and may be appropriately selected depending on the purpose. Note that, the pH can be adjusted by varying a quantity ratio of the carboxylic acid and the carboxylate.

25 The pH of the suspension in the extraction step is not particularly limited and may be appropriately selected depending on the purpose, but is preferably in the range of pH 2.0 to pH 10.0, more preferably in the range of pH 4.0 to pH 9.5,

particularly preferably in the range of pH 5.0 to pH 8.0, from the viewpoint of extraction efficiency of iron.

A temperature of the suspension during the extraction step is not particularly limited and may be appropriately selected depending on the purpose, but is preferably in the range of 30°C to 100°C, more preferably in the range of 50°C to 100°C, particularly preferably in the range of 70°C to 100°C, from the viewpoint of extraction efficiency of iron.

An extraction time in the extraction step is not particularly limited and may be appropriately selected depending on the purpose.

The iron-extraction rate (hereinafter may be referred to as “iron-elution rate”) in the extraction step is not particularly limited and may be appropriately selected depending on the purpose, but is preferably high as possible. Specifically, the rate is preferably 16% by mass or more, more preferably 25% by mass or more, particularly preferably 60% by mass or more.

The iron-extraction rate can be calculated according to the following equation.

Iron-extraction rate (%) = {Total amount (mass) of iron in extract / Total amount (mass) of iron contained in yeast used for extraction} × 100
<<Suspension>>

A means of suspending the yeast in the solution containing the carboxylic acid, the carboxylate, or both thereof is not particularly limited. For example, known means of agitating or shaking may be used.

In the extraction step, the suspension may be further shaken. The condition is not particularly limited and may be appropriately selected depending on the purpose.

<<Separation into solid component and liquid component>>

A means of separating the suspension into a solid component and a liquid

component is not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include filtration or centrifugation.

A means of filtration is not particularly limited. Known filtration devices may be appropriately selected and used. Examples of the devices include a filter
5 press and a line filter. These may be used in combination.

A means of centrifugation is not particularly limited. Known centrifugation devices may be appropriately selected and used. The condition is not particularly limited and may be appropriately selected depending on an amount of the suspension. For example, in the case where the amount of the suspension is
10 5 mL, the centrifugation is performed at 3,000 rpm for 5 min.

After extraction with the carboxylic buffer, the carboxylic acid remains in the iron-rich yeast extract as extraction traces. Therefore, the carboxylic acid contained in the iron-rich yeast extract can be measured to determine whether the extraction with the buffer has been achieved. A method for measuring is not
15 particularly limited. For example, an amount of the carboxylic acid can be measured using HPLC (high performance liquid chromatography).

<Other steps>

The other steps are not particularly limited and may be appropriately selected depending on the purpose, as long as they do not impair the effects of the
20 present invention. Examples thereof include a hot-water treatment step, a drying step, a concentration step, and a dilution step. Among them, the hot-water treatment step is preferably comprised.

<<Hot-water treatment step>>

The hot-water treatment step comprises suspending the yeast containing
25 iron in hot-water of 60°C to 120°C to thereby obtain a suspension, and separating the suspension into a solid component and a liquid component, prior to the extraction step. Performing the hot-water treatment step prior to the extraction

step can reduce the odor and the taste which are distinctive of yeast (i.e., yeast odor and yeast taste), and a taste of food to which the resultant iron-rich yeast extract has been added is not impaired, which is preferable.

A temperature of the hot-water is not particularly limited and may be appropriately selected depending on the purpose, but is preferably 80°C to 120°C, more preferably 95°C to 120°C from the viewpoint of an excellent effect of reducing the yeast odor and the yeast taste.

A method for suspending the yeast and a method for separating the resultant suspension into the solid component and the liquid component are not particularly limited. For example, the methods described for the extraction step may be used.

In the hot-water treatment step, an extraction accelerator for accelerating extraction (removal) of the yeast odor and the yeast taste is preferably added to the hot water in order to reduce the odor and taste which are distinctive of yeast. The accelerator is not particularly limited and may be appropriately selected depending on the purpose, as long as it does not adversely affect the iron-extraction rate in the subsequent extraction step. Examples thereof include salts other than carboxylates. Among them, phosphates are preferable because they are superior in extraction of the yeast odor, but are less likely to accelerate extraction of iron in the hot water step.

An amount of the accelerator to be added is not particularly limited and may be appropriately selected depending on the purpose, but is preferably 5% by mass to 50% by mass, more preferably 20% by mass to 50% by mass, relative to dry mass of the yeast.

<<Drying step, concentration step, dilution step>>

The drying step comprises drying the iron-rich yeast extract.

A means of drying is not particularly limited and may be appropriately

selected depending on the purpose. For example, SPRAY DRIER L-8 (OHKAWARA KAKOHKI CO., LTD.) may be used. The drying step can result in a solid (powder) of the iron-rich yeast extract, which can be used in various applications described below. During the drying step, an excipient (e.g., dextrin) may be appropriately
5 added.

The concentration step comprises concentrating the iron-rich yeast extract. The dilution step comprises diluting the iron-rich yeast extract.

A means of concentrating and a means of diluting are not particularly limited and may be conventionally known methods.

10 (Iron-rich yeast extract)

An iron-rich yeast extract of the present invention is an extract which contains 0.2% by mass or more of iron derived from yeast, and which has a turbidity of 0.1 or less in terms of absorbance at 660 nm (O. D. 660) when 1 g of the extract is dissolved or dispersed into 100 mL of water.

15 A method for producing the iron-rich yeast extract is not particularly limited and may be appropriately selected depending on the purpose. However, the extract can be suitably produced by the method of the invention. That is, the iron-rich yeast extract is preferably produced by subjecting iron-containing yeast to extraction with a solution containing a carboxylic acid, a carboxylate, or both
20 thereof.

<Iron content>

The iron content in the extract is preferably high as possible from the viewpoint of use of the extract as an iron-enriched food material. "Iron-rich," as used herein, means that iron derived from yeast is contained in a concentration of
25 0.2% by mass or more, preferably 0.5% by mass or more, more preferably 0.7% by mass or more.

Containing iron in such a high concentration allows the extract to be

suitably used as an oral or tube feeding composition (e.g., a fluid diet or a beverage) or a food material.

The iron content can be measured by known methods such as an atomic absorption spectrometry or an ICP emission spectrometric analysis.

5 <Turbidity>

The iron-rich yeast extract of the present invention has a high water-solubility, so that an aqueous solution of the extract has a high transparency. The extract has a turbidity of 0.1 or less, preferably 0.08 or less, more preferably 0.05 or less in terms of absorbance at 660 nm (O. D. 660) when 1 g of the extract is
10 dissolved or dispersed into 100 mL of water. When the turbidity is more than 0.1, food to which the extract is added may get turbid and be discolored, which may impair appearance of the food. In addition, the iron-rich yeast extract has insufficient water-solubility and may precipitate, which may be problematic in the case where the extract is used in food required to be transparent (in particular, soft
15 drink).

A form of the iron-rich yeast extract is not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include a liquid form (extraction liquid such as filtrate or supernatant) obtained through the extraction step; a solid form such as powder, particle, or sheet; and a semi-solid
20 form such as gel or a slurry. In the measurement of the turbidity, "1 g of the iron-rich yeast extract" is in the form of a dried solid of which moisture content is 7% by mass or less. A means of drying is not particularly limited and may be any of the above-described methods. The condition is not particularly limited.

The turbidity can be measured as absorbance at 660 nm (O. D. 660) by using
25 a spectrophotometer. Example of the spectrophotometer includes U-2000 model (Hitachi, Ltd.).

<Application>

Application of an iron-rich yeast extract of the present invention is not particularly limited and may be appropriately selected depending on the purpose. The extract is preferably used as a food material to be added to food, animal food, or feed, more preferably used as the food material. Among the food materials, the extract of the invention is preferably used in the fluid diet or the soft drink from the viewpoint of excellent solubility. The iron-rich yeast extract of the invention can result in iron-rich food, iron-rich animal food, iron-rich feed, and the like. Also, other applications of the iron-rich yeast extract of the invention include additives to food fermentation media and the like.

A form of the iron-rich yeast extract in use is not particularly limited and may be appropriately selected depending on the application. Examples thereof include a dried powder (e.g., extract dried using, e.g., a spray drier), a solution form in which the extract is dissolved in a solvent, and a semi-solid form (e.g., a gel or cream). A method for preparing the iron-rich yeast extract into the above-described forms is not particularly limited and can be performed using known devices according to known methods.

(Food)

Food of the present invention contains the iron-rich yeast extract of the invention; and, if necessary, further contains other ingredients.

The "food," as used herein, refers to those having a low possibility of being harmful to human health, and being ingested via oral or gastrointestinal administration in an ordinary social life, which is not limited by administrative classification such as food, medicine, or quasi drug. For example, the food encompasses a wide range of orally ingested general food, health food, food with health claims, quasi drug and medicine.

A type of the food is not particularly limited and may be appropriately selected depending on the purpose, but is preferably a fluid diet, bread,

confectionery such as a biscuit or a cracker, a processed marine product, a processed meat product, noodles, a seasoning such as miso, a processed vegetable product, a beverage such as juice, ices such as ice cream, and health food, particularly preferably the fluid diet or the beverage.

5 An amount of the iron-rich yeast extract contained in the food is not particularly limited and may be appropriately selected depending on the application and purpose.

 The other ingredients are not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include auxiliary materials
10 or additives generally used in production of the food.

 The auxiliary materials or additives are not particularly limited and may be appropriately selected depending on the purpose. Examples thereof include glucose, fructose, sucrose, maltose, sorbitol, stevioside, rubusoside, corn syrup, lactose, citric acid, tartaric acid, malic acid, succinic acid, lactic acid, L-ascorbic
15 acid, dl- α -tocopherol, sodium erythorbate, glycerin, propylene glycol, glycerine fatty acid ester, polyglycerin fatty acid ester, sucrose fatty acid ester, sorbitan fatty acid ester, gum arabic, carrageenan, casein, gelatin, pectin, agar, vitamin B, nicotinic acid amide, calcium pantothenate, amino acids, calcium salts, a pigment, a perfume, and a preservative.

20 An amount of the other ingredients is not particularly limited and may be appropriately selected depending on the purpose.

Examples

 Examples of the present invention now will be described, but the invention
25 is not limited thereto.

(Test Example 1: extraction-1 of iron with carboxylate)

To 5 g (dry mass) of an iron-rich yeast powder (MINERAL YEAST Fe, iron

content: 15,390 ppm by mass, Oriental Yeast Co., Ltd.), was added 50 mL of each of aqueous solutions of sodium carboxylate described in Table 1 at 200 mmol/L, followed by stirring and diluting up to 100 mL to obtain a suspension. An amount of each of the sodium carboxylate was 7.3 mol relative to 1 mol of iron contained in yeast to be extracted. Water or a 200 mmol/L aqueous solution of sodium chloride (table salt) was used as a control and was tested in the same manner as the suspension. The suspension was measured for pH using a pH meter (MP230, METTLER-TOREDO Inc.).

Under stirring with a stirrer, 5 mL of the suspension was taken out into a test tube, followed by heating in a boiling water bath for 10 min. The resultant suspension is centrifuged at 3,000 rpm for 5 min. Only supernatant was transferred to a test tube to thereby obtain a yeast extract. The extract was weighed.

The iron content was determined by measuring iron in the extract through an ICP emission spectrometric analysis using an ICP emission spectrophotometer (OPTIMA 2100DV, PerkinElmer Inc.), from which a rate of iron extracted to the extract was calculated. Results are shown in Table 1 and FIG. 1.

The extract was dried to powder to obtain a dried powder. The iron content on the powder basis (% by mass) was measured as follows. That is, dextrin was added to the extract which had been subjected to extraction, followed by adjusting a solid content to 10% by mass. Then, the resultant was dried using SPRAY DRIER L-8 (OHKAWARA KAKOHKI CO., LTD.), and quantified for iron by the ICP emission spectrometric analysis using the ICP emission spectrophotometer (OPTIMA 2100DV, PerkinElmer Inc.). Results are shown in Table 1.

Table 1

	Extraction solvent	pH of suspension	Iron extraction rate (%)	Iron content of dried powder (% by mass)
Test Example 1-1	Pure water	5.4	5	0.0
Test Example 1-2	Sodium chloride (table salt) solution	5.3	7	0.1
Test Example 1-3	Sodium L-tartrate solution	5.7	27	0.2
Test Example 1-4	Trisodium citrate solution	7.1	73	0.7

As shown in Table 1 and FIG. 1, use of carboxylates results in a high iron extraction rate and an iron-rich extract.

5 (Test Example 2: extraction-2 of iron with carboxylate)

To 1 g (dry mass) of an iron-rich yeast powder (MINERAL YEAST Fe, iron content: 15,390 ppm by mass, Oriental Yeast Co., Ltd.), was added 10 mL of each of aqueous solutions of sodium carboxylates described in Table 2 at 200 mmol/L, followed by stirring, adjusting to the specified pH, and diluting up to 20 mL to
 10 obtain a suspension. An amount of each of the sodium carboxylates relative to 1 mol of iron contained in the yeast was as shown in Table 2. The pH was adjusted while being measured with the pH meter (MP230, METTLER-TOREDO Inc.).

The suspension was shaken (with a stirrer) at 20°C for 2 hours.

Thereafter, under stirring with the stirrer, 5 mL of the suspension was
 15 taken out into a test tube, followed by heating in a boiling water bath for 10 min. The resultant suspension is centrifuged at 3,000 rpm for 5 min. Only supernatant was transferred to a test tube to obtain yeast extract. The yeast extract was weighed.

The iron content was determined by measuring iron in the extract through
 20 the ICP emission spectrometric analysis using the ICP emission spectrophotometer (OPTIMA 2100DV, PerkinElmer Inc.), from which a rate of iron extracted to the extract was calculated. Results are shown in Table 2 and FIG. 2.

A dried powder of the extract was obtained and measured for an iron

content in the extract in the same manner as in Test Example 1. Results are shown in Table 2.

Table 2

	Extraction solvent	Molar ratio (Carboxylate/Iron)	pH of suspension	Iron extraction rate (%)	Iron content of dried powder (% by mass)
Test Example 2-1	Sodium acetate (anhydrous) solution	7.3	2.1	19	0.2
Test Example 2-2	Sodium gluconate solution	7.3	2.2	21	0.2
Test Example 2-3	Sodium gluconate solution	7.3	8.3	23	0.2
Test Example 2-4	Sodium gluconate solution	7.3	10.1	27	0.3
Test Example 2-5	Sodium L-tartrate solution	7.3	2.0	24	0.2
Test Example 2-6	Sodium L-tartrate solution	7.3	5.7	27	0.2
Test Example 2-7	Sodium L-tartrate solution	7.3	8.4	27	0.3
Test Example 2-8	Sodium L-tartrate solution	7.3	10.0	17	0.2
Test Example 2-9	Monosodium succinate solution	7.3	2.1	21	0.2

As shown in Table 2 and FIG. 2, use of sodium acetate, sodium gluconate, and sodium succinate as the carboxylates also results in a high iron-extraction rate and a high iron content in the extract.

(Test Example 3: effect of extraction temperature on iron-extraction rate)

MINERAL YEAST Fe powder (iron content: 15,390 ppm by mass, Oriental Yeast Co., Ltd.) was suspended in 300 mL of water to thereby obtain 40% by mass of cream. The cream was heated for 10 min in a boiling water bath, followed by washing. The resultant precipitate was diluted up to 300 mL. Then, 10 mL of the

cream was added to and suspended in 10 mL of each of aqueous solutions containing citric acid and trisodium citrate dihydrate (citric buffers), to thereby obtain a suspension. Note that, the citric buffers had a concentration of 200 mmol/L, and the pH of each of the citric buffers was adjusted to 4.5.

Two hours after adjusting each of the citric buffers to 4°C, 50°C, or 75°C, the suspension was subjected to centrifugation. The supernatant (yeast extract) was measured for the iron-extraction rate in the same manner as in Test Example 1. Additionally, a dried powder of the extract was obtained and measured for an iron content in the extract in the same manner as in Test Example 1. Results are shown in Table 3 and FIG. 3.

Table 3

	pH of suspension	Temperature of suspension (°C)	Iron extraction rate (%)	Iron content of dried powder (% by mass)
Test Example 3-1	4.7	4	27	0.3
Test Example 3-2	4.7	50	75	0.7
Test Example 3-3	4.6	75	84	0.8

As shown in Table 3 and FIG. 3, there is a trend that the higher the temperature of the suspension is, the higher the iron-extraction rate is. However, a high iron-extraction rate of 20% or higher could be attained in a broad temperature range, that is, the iron-rich yeast extract could be obtained. (Test Example 4: effect of pH on iron-extraction rate)

Supernatants (yeast extracts) were obtained in the same manner as in Test Example 3 except that the citric buffer was changed to each of the aqueous solutions (citric buffers) shown in Table 4 and the temperature of the suspension was adjusted to 75°C. Note that, the pH of each of the citric buffers was adjusted by appropriately varying a quantity ratio of citric acid and trisodium citrate dihydrate.

In the same manner as in Test Example 1, the supernatants (yeast extracts)

were measured for the iron-extraction rate. Additionally, in the same manner as in Test Example 1, a dried powder of each of the extracts was obtained and measured for an iron content in the extract. Results are shown in Table 4 and FIG. 4.

Table 4

	pH of aqueous solution containing citric acid, trisodium citrate, or both thereof (citric acid buffer)	pH of suspension	Iron extraction rate (%)	Iron content of dried powder (% by mass)
Test Example 4-1	2.0 (only citric acid)	2.7	22	0.3
Test Example 4-2	3.0	3.4	39	0.5
Test Example 4-3	3.5	3.8	52	0.6
Test Example 4-4	4.0	4.2	66	0.8
Test Example 4-5	4.5	4.7	77	0.9
Test Example 4-6	5.0	5.2	85	1.0
Test Example 4-7	5.5	5.8	85	1.0
Test Example 4-8	6.0	6.4	88	1.1
Test Example 4-9	6.5	6.8	92	1.1
Test Example 4-10	7.8 (only trisodium citrate)	7.1	94	1.1
Test Example 4-11	8.0	8.4	68	0.8
Test Example 4-12	9.0	9.1	62	0.7
Test Example 4-13	10.0	9.9	31	0.4

5

As shown in Table 4 and FIG. 4, there is a trend that the closer the pH of a solvent for extraction (carboxylic buffer) is to the neutral pH, the higher the iron-extraction rate is. However, a high iron-extraction rate of 20% or higher could be attained in a broad pH range, that is, the iron-rich yeast extract could be obtained. Iron could be extracted at a high rate in all cases where the solvent contains only a carboxylic acid, both of a carboxylic acid and a carboxylate, and only a carboxylate, resulting in the iron-rich yeast extract.

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(Test Example 5: effect of relationship between iron content in yeast and total amount of carboxylic acid and carboxylate, on iron-extraction rate)

MINERAL YEAST Fe (iron content: 15,390 ppm by mass, Oriental Yeast Co., Ltd.) was used as a raw material to test a relationship between a total amount of a carboxylic acid and a carboxylate and the extraction efficiency of iron.

Trisodium citrate was used as a carboxylate contained in an extraction solvent to prepare aqueous solutions of trisodium citrate having concentrations shown in Table 5. The pH of each of the solutions of trisodium citrate was adjusted to 7.8.

Supernatants (yeast extracts) were obtained in the same manner as in Test Example 3, except that the aqueous solutions of trisodium citrate having the concentrations shown in Table 5 were used and that the temperature of the suspension was adjusted to 75°C. The yeast extracts were measured for the iron-extraction rate.

In the same manner as in Test Example 1, the supernatants (yeast extracts) were measured for the iron-extraction rate. Additionally, in the same manner as in Test Example 1, a dried powder of each of the extracts was obtained and measured for an iron content in the extract. Results are shown in Table 5 and FIG. 5. Note that, in FIG. 5, a "black diamond" denotes an iron-extraction rate, and a "black square" denotes a pH of suspension.

Table 5

	Concentration of trisodium citrate in aqueous solution (mmol/L)	Molar ratio (Total of citric acid and citrate /Iron)	pH of suspension	Iron extraction rate (%)	Iron content of dried powder (% by mass)
Test Example 5-1	0	0.0	7.3	3	0.0
Test Example 5-2	100	2.7	7.0	82	1.0
Test Example 5-3	150	4.1	7.1	86	1.0
Test Example 5-4	200	5.4	7.2	83	1.0
Test Example 5-5	300	8.2	7.1	86	1.0
Test Example 5-6	400	10.9	7.2	86	1.0
Test Example 5-7	600	16.3	7.2	78	0.9

As shown in Table 5 and FIG. 5, a very high iron-extraction rate could be attained in the case where the total of the carboxylic acid and the carboxylate was a certain amount or more relative to 1 mol of iron contained in the yeast.

(Test Example 6: evaluation of solubility)

One gram of the iron-rich yeast extract powder obtained in Test Example 4-10 was diluted to 100 mL with water or apple juice beverage (beverage containing 10% by volume apple juice, ASAHI SOFT DRINKS CO., Ltd.) to thereby prepare a 1% (mass/volume) solution of the iron-rich yeast extract (test solution).

The prepared solutions were each measured for turbidity by measuring absorbance at 660 nm (O. D. 660) using the spectrophotometer (U-2000 model, Hitachi, Ltd.).

The solutions were each observed for the presence or absence of a precipitate after centrifugation at 3,000 rpm for 5 min.

MINERAL YEAST Fe which had not been subjected to extraction (Oriental Yeast Co., Ltd.) was used as control solutions (suspensions) having the same iron content as the test solutions, and the control solutions each were measured for

turbidity and evaluated for the presence or absence of a precipitate in the same manner as in the test solution. Results are shown in Table 6, FIG. 6A (aqueous solution prior to centrifugation), FIG. 6B (aqueous solution after centrifugation), FIG. 6C (apple juice solution prior to centrifugation), and FIG. 6D (apple juice solution after centrifugation).

Table 6

	Sample	Solvent	O. D. 660 (1% solution)	Visual evaluation	Visual evaluation after centrifugation
Test Example 6-1	Iron-rich yeast extract	Water	0.02	Aqueous solution with high clarity	Precipitate was not confirmed
Test Example 6-2	MINERAL YEAST Fe	Water	10.54	Suspended	Precipitate was confirmed (yeast)
Test Example 6-3	Iron-rich yeast extract	Apple juice	0.02	Aqueous solution with high clarity	Precipitate was not confirmed
Test Example 6-4	MINERAL YEAST Fe	Apple juice	8.99	Suspended	Precipitate was confirmed (yeast)

The aqueous solution of Test Example 6-1 had significantly lower turbidity than the aqueous solution of Test Example 6-2. As shown in FIG. 6A, it was visually confirmed that the aqueous solution of Test Example 6-1 had significantly higher clarity than the solution of Test Example 6-2. As shown in FIG. 6B, after centrifugation at 3,000 rpm for 5 min, the solution of Test Example 6-1 contained no precipitate and was a solution with high clarity. In contrast, the solution of Test Example 6-2 contained a precipitate.

The same results could be obtained in Test Examples 6-3 and 6-4 each using apple juice instead of water.

Therefore, the iron-rich yeast extract of the present invention has high solubility in water and the like, so that it can be added to, for example, a fluid diet or a beverage. Additionally, the extract of the invention does not cause turbidity and discoloration, so that it does not impair appearance of food containing it and can also be added to, in particular, a soft drink having a high transparency.

(Test Example 7: evaluation of odor and taste)

The following test samples were prepared: the iron-rich yeast extract powder obtained in Example 4-10 (hereinafter referred to as "powder"); a 1% (mass/volume) aqueous solution of the powder; a solution prepared by dissolving the powder in apple juice (beverage containing 10% by volume apple juice, ASAHI SOFT DRINKS CO., Ltd.) so as to have a concentration of 1% (mass/volume) (hereinafter referred to as "apple juice"); a solution prepared by dissolving the powder in an aqueous solution of modified milk powder (CHIL MIL, MORINAGA MILK INDUSTRY CO., LTD.) so as to have a concentration of 1% (mass/volume), the solution of modified milk powder being prepared by dissolving or suspending 14 g of the modified milk powder in 100 mL of water (hereinafter referred to as "milk"); and a mixture prepared by adding the powder to a nutritional adjustment food (MEIBALANCE (yogurt taste), Meiji Co., Ltd.) so as to have a concentration of 1% (mass/volume) (hereinafter referred to as "fluid diet").

<Evaluation method>

The powder, the 1% solution of the powder, the apple juice, the milk, and the fluid diet were evaluated for odors ("metal odor/unpleasant odor") and tastes ("metal taste/off-taste/harsh taste") by 5 evaluators. Note that, the powder of the iron-rich yeast extract was evaluated only for odors.

MINERAL YEAST Fe (Oriental Yeast Co., Ltd.) which had not been subjected to extraction was used as control samples having the same iron content as the test samples, and the control samples each were evaluated in the same manner as the test samples.

<<Evaluation-1>>

For the powder, the 1% solution of the powder, and the apple juice, each sample (MINERAL YEAST Fe) was ranked for evaluation items by 5 evaluators according to the following criteria, assuming that the iron-rich yeast extract was

ranked as 3 (standard) for each of the evaluation items, followed by averaging.
Results are shown in Table 7-1.

-Evaluation criteria for odor ("metal odor/unpleasant odor")-

5: very strong

5 4: strong

3: comparable

2: weak

1: very weak

-Evaluation criteria for taste ("metal taste/off-taste/harsh taste")-

10 5: very strong

4: strong

3: comparable

2: weak

1: very weak

15 <<Evaluation-2>>

For the milk and the fluid diet, each sample (iron-rich yeast extract and MINERAL YEAST Fe) was ranked for evaluation items by 5 evaluators according to the following criteria, assuming that a no-additive sample was ranked as 3 (standard) for each of the evaluation items, followed by averaging. Results are shown in Table 7-2.

-Evaluation criteria for odor ("metal odor/unpleasant odor")-

5: very strong

4: strong

3: comparable

25 2: weak

1: very weak

-Evaluation criteria for taste ("metal taste/off-taste/harsh taste")-

5: very strong

4: strong

3: comparable

2: weak

1: very weak

Table 7-1

	Sample	Food				
		Powder	1% solution of powder		Apple juice	
		Metal odor/ Unpleasant odor	Metal odor/ Unpleasant odor	Metal taste/Off- taste/harsh taste	Metal odor/ Unpleasant odor	Metal taste/Off- taste/Harsh taste
Test Example 7-1	Iron-rich yeast extract	3.0	3.0	3.0	3.0	3.0
Test Example 7-2	MINERAL YEAST Fe	4.2	4.4	4.4	4.0	4.2

Table 7-2

	Sample	Food			
		Milk		Fluid diet	
		Metal odor/ Unpleasant odor	Metal taste/ Off-taste/ Harsh taste	Metal odor/ Unpleasant odor	Metal taste/ Off-taste/ Harsh taste
Control	No additive	3.0	3.0	3.0	3.0
Test Example 7-1	Iron-rich yeast extract	3.4	3.4	3.0	3.6
Test Example 7-2	MINERAL YEAST Fe	4.0	4.4	4.0	4.6

As shown in Tables 7-1 and 7-2, Test Example 7-1 containing the iron-rich yeast extract, which is one aspect of the invention, could be sufficiently reduced as compared with Test Example 7-2 containing MINERAL YEAST Fe in terms of non-food odors such as a metal odor and an unpleasant odor and non-food tastes such as a metal taste, an off-taste, and a harsh taste, and thus is very excellent. Therefore, it can be used sufficiently as a food material.

Industrial Applicability

An iron-rich yeast extract of the present invention contains iron derived

from a natural product in a high concentration, is excellent in water-solubility, is sufficiently reduced in terms of non-food odors such as a metallic odor and an unpleasant odor and non-food tastes such as a metallic taste, an off-taste, and a harsh taste, does not impair appearance of food containing it, and does not impair a
5 flavor of food containing it, and hence is suitable for an oral or tube feeding composition (e.g., fluid diet and beverage) or a food material capable of improving anemia and deterioration in motor function and cognitive function associated with iron deficiency.

According to a method for producing an iron-rich yeast extract of the
10 invention, iron can be extracted at a high rate from iron-containing yeast, resulting in an efficient production of an iron-rich yeast extract.

CLAIMS

1. A method for producing an iron-rich yeast extract, comprising:
hot-water treating iron-containing yeast, which is prepared by incorporating iron into yeast, by suspending the yeast in hot-water of 60°C to 120°C to thereby obtain a first suspension, and separating the first suspension into a solid component and a liquid component to thereby obtain the solid component; and
suspending the solid component obtained in the hot-water-treating in a solution containing a carboxylic acid, a carboxylate, or both thereof to thereby obtain a second suspension, and separating the second suspension into a solid component and a liquid component to thereby obtain the liquid component containing iron.
2. The method according to claim 1, wherein the carboxylic acid is a monovalent to trivalent carboxylic acid, and wherein the carboxylate is a monovalent to trivalent carboxylate.
3. The method according to claim 1 or 2, wherein the carboxylic acid is citric acid, and wherein the carboxylate is trisodium citrate.
4. The method according to any one of claims 1 to 3, wherein the iron-containing yeast is a dry yeast powder.
5. The method according to any one of claims 1 to 4, wherein a temperature of the suspension during the extracting is in the range of 30°C to 100°C.
6. The method according to any one of claim 1 to 5, wherein a pH value of the suspension during the extracting is in the range of 4.0 to 9.5.
7. The method according to any one of claims 1 to 6, wherein a total amount of the carboxylic acid and the carboxylate is in the range of 2.0 mol to 17.0 mol relative to 1 mol of iron contained in the yeast.
8. The method according to any one of claims 1 to 7, wherein in the hot-water treating, a phosphoric acid salt is added to the hot-water.
9. The method according to any one of claims 1 to 8, wherein the iron-rich yeast extract contains 0.2% by mass or more of iron derived from yeast, and wherein a turbidity is 0.1 or less in terms of absorbance at a wavelength of 660 nm (O. D. 660) when 1 g of the iron-rich yeast extract is dissolved or dispersed into 100 mL of water.

10. A method for producing food, wherein the method uses an iron-rich yeast extract produced by the method according to any one of claims 1 to 9.