

OAT-BASED FREEZE-DRIED YOGURT BITES AND PREPARATION METHOD THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates to the technical field of plant-based yogurt processing, and specifically relates to an oat-based freeze-dried yogurt bites and a preparation method thereof.

BACKGROUND

[0002] Inner Mongolia is one of the origins of oats in the world and the largest oat production base in China. Oats are regarded as a high-nutrient, high-energy, and low-sugar food. According to data from the China Food and Drug Administration (CFDA), there are 47 kinds of domestic health foods and 4 kinds of imported health foods that use oats as a functional raw material. Oats are nutritionally complete. Compared with common food crops in people's lives such as wheat, rice, and corn, oats have the highest content of nutrients such as proteins, greases, soluble dietary fiber (β -glucan), vitamins, and minerals. Compared with other cereal proteins, oat proteins have a higher bioavailability *in vivo*, and the essential amino acid composition is basically the same as the recommended daily intake. Therefore, oats shows the most balanced amino acid composition among all cereals. Oat greases are rich in high-quality fatty acids, with unsaturated fatty acids accounting for not less than 80% of total fatty acids and have the effects of significantly lowering blood lipids and total cholesterol levels as well as protecting from cardiovascular and cerebrovascular diseases. Oats also have a total dietary fiber content of 17% to 21%, of which a soluble dietary fiber is mainly β -glucan accounting for about 1/3 of the total dietary fiber, and is 7 times higher the β -glucan content in rice and wheat. β -glucan is one of the ingredients that distinguishes oats from other cereals, and is also an important manifestation for the nutritional value of oats. A large number of reports have confirmed that oat β -glucan has the functions of lowering blood sugar, softening blood vessels, preventing hypertension, enhancing the body's immunity, and preventing cardiovascular diseases. In addition, oat β -glucan also shows a probiotic effect in promoting the proliferation of beneficial flora such as *Bifidobacterium* and *Lactobacillus*, while inhibiting the growth of harmful intestinal flora such as *Escherichia coli*. Oats are also a desirable source of antioxidant substances such as phenols. The antioxidant ingredients in oat are mainly phenolic acids, vitamin E, flavonoids, sitosterol, oat alkaloids (anthracene amides), and phytic acids. Oat phenols show desirable antioxidant properties and strong capacities to scavenge free radicals, and also inhibit the oxidation of low-density lipoproteins and lower the blood lipids to prevent cardiovascular diseases. The rich nutrients contained in oats provide an excellent foundation for the growth of *Lactobacillus*.

[0003] At present, most of the oat fermented products reported at home and abroad adopt oats as a main raw material, which is added with milk, sterilized, and inoculated with lactic acid bacteria to allow fermentation to produce a series of products such as oat yogurt bites. Since yogurt bites fermented by lactic acid bacteria from simple oats have poor flavor and cannot be accepted by people, there are extremely rare yogurt bites products prepared by fermentation entirely from oats. In view of this, there is an urgent need to invent an oat fermentation product that solves the above technical problems.

SUMMARY

[0004] An objective of the present disclosure is to provide oat-based freeze-dried yogurt bites and a preparation method thereof. The present disclosure solves the problems of short shelf life, poor mouth feel, and single taste of oat yogurt. The product is not only crispy and delicious, but also contains active lactic acid bacteria, and also improves the availability and added value of oats.

[0005] To achieve the above objective, the present disclosure provides the following technical solutions:

[0006] The present disclosure provides a preparation method of an oat-based freeze-dried yogurt, including the following steps:

[0007] A) preparing an oat thick slurry, comprising mixing an oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, and high-temperature amylase with water, heating to 95°C, and wet-grinding to obtain the oat thick slurry;

[0008] B) conducting enzymatic hydrolysis, comprising mixing the oat thick slurry with α -amylase and a debittering enzyme, adjusting a pH value of a resulting mixture to 6.80 to 7.00, and conducting the enzymatic hydrolysis at 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0009] C) conducting homogenization, comprising adding an oat oil into the enzymatic hydrolyzate, stirring for 5 min, and conducting the homogenization at 60°C to 70°C and 20 MPa;

[0010] D) conducting pasteurization;

[0011] E) conducting fermentation, comprising inoculating a compound microorganism into a feed liquid obtained after pasteurization, and conducting fermentation at 41°C to 43°C for 4 h to 6 h;

[0012] F) conducting blending, comprising blending an obtained fermented feed liquid with freeze-dried oatmeal, jam, and water to obtain a blended feed liquid;

[0013] G) conducting vacuum freeze-drying, comprising pouring the blended feed liquid into a mold to allow pre-freezing and freeze-drying in sequence to obtain a semi-finished product of the oat-based freeze-dried yogurt; and

[0014] H) coating with a chocolate, comprising coating the semi-finished product with natural

cocoa butter chocolate to obtain the oat-based freeze-dried yogurt bites.

[0015] Preferably, the oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, high-temperature amylase, and water are mixed in a mass ratio of 35:1:1:0.1:100.

[0016] Preferably, α -amylase, the debittering enzyme, and the oat core powder are mixed in a mass ratio of 0.05:0.1:100.

[0017] Preferably, the oat oil is added at 10% of a mass of the oat core powder.

[0018] Preferably, pasteurization is conducted at 95°C for 5 min.

[0019] Preferably, the compound microorganism includes *Lactobacillus delbrueckii*, *Streptococcus thermophilus*, and *Lactobacillus plantarum* in a mass ratio of 1:1:1, and is inoculated in an inoculum size of 0.05%.

[0020] Preferably, the blended feed liquid has an oat solid content of 15%; and the jam has a volume of 20% of the blended feed liquid, and the freeze-dried oatmeal has a volume of 20% of the blended feed liquid.

[0021] Preferably, the pre-freezing is conducted at -35°C to -45°C for 4 h to 6 h; and the freeze-drying refers to vacuum freeze-drying including sublimation conducted at -25°C to 0°C for 24 h and secondary vacuum drying conducted at 0°C to 35°C for 24 h.

[0022] The present disclosure further provides oat-based freeze-dried yogurt bites prepared by the preparation method.

[0023] Compared with the prior art, the present disclosure has the following beneficial effects:

[0024] The present disclosure provides a preparation method of oat-based freeze-dried yogurt bites, including the following steps: preparing an oat core powder into an oat thick slurry, and then subjecting the oat thick slurry to enzymatic hydrolysis, homogenization, pasteurization, fermentation, blending, vacuum freeze-drying, and coating with chocolate sequentially to obtain the oat-based freeze-dried yogurt bites. The oat core powder prepared from pure oats is used as the raw material. A variety of volatile flavor components formed during the fermentation, such as acetic acid and butyric acid, can reflect a unique taste of fermentation, such that a resulting product has a flavor of yogurt and a unique aroma of the oats and is rich in nutrients and easy to be digested and absorbed. This method can also improve the performance of the oats, thus meeting people's needs for physiological health and balanced nutritional diet and greatly increase an added value of oat products. The present disclosure solves the problems of short shelf life, poor mouth feel, and single taste for oat yogurt. The product is not only crispy and delicious, but also contains active lactic acid bacteria, and also improves the availability and added value of oats.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] The present disclosure provides a preparation method of an oat-based freeze-dried yogurt

bites, including the following steps:

[0026] A) preparing an oat thick slurry: mixing an oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, and high-temperature amylase with water, heating to 95°C, and wet-grinding to obtain the oat thick slurry;

[0027] B) conducting enzymatic hydrolysis: mixing the oat thick slurry with α -amylase and a debittering enzyme, adjusting a pH value of a resulting mixture to 6.80 to 7.00, and conducting the enzymatic hydrolysis at 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0028] C) conducting homogenization: adding an oat oil into the enzymatic hydrolyzate, stirring for 5 min, and conducting the homogenization at 60°C to 70°C and 20 MPa;

[0029] D) conducting pasteurization;

[0030] E) conducting fermentation: inoculating a compound microorganism into a feed liquid obtained after pasteurization, and conducting fermentation at 41°C to 43°C for 4 h to 6 h;

[0031] F) conducting blending: blending an obtained fermented feed liquid with freeze-dried oatmeal, jam, and water to obtain a blended feed liquid;

[0032] G) conducting vacuum freeze-drying: pouring the blended feed liquid into a mold to allow pre-freezing and freeze-drying in sequence to obtain a semi-finished product of the oat-based freeze-dried yogurt; and

[0033] H) chocolate coating: coating the semi-finished product with natural cocoa butter chocolate to obtain the oat-based freeze-dried yogurt.

[0034] In the present disclosure, the oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, the high-temperature amylase, and the water are mixed in a mass ratio of preferably 35:1:1:0.1:100.

[0035] In the present disclosure, α -amylase, the debittering enzyme, and the oat core powder are mixed in a mass ratio of preferably 0.05:0.1:100; the oat oil is added at preferably 10% of a mass of the oat core powder; pasteurization is conducted at preferably 95°C for preferably 5 min; and the oat core powder is a Wuchuan naked oat core powder. The enzymatic hydrolysis can obtain sugars and remove a bitter taste of the Wuchuan naked oat core powder. The homogenization process improves color (whitening), taste, and aroma.

[0036] In the present disclosure, the compound microorganism includes *Lactobacillus delbrueckii*, *Streptococcus thermophilus*, and *Lactobacillus plantarum* in a mass ratio of preferably 1:1:1, and is inoculated in an inoculum size of preferably 0.05%; and a fermentation end point is preferably determined when a pH value is less than or equal to 4.6. *Lactobacillus delbrueckii*, *Streptococcus thermophilus*, and *Lactobacillus plantarum* each are purchased from Chr. Hansen.

[0037] In the present disclosure, *Lactobacillus delbrueckii* and *Streptococcus thermophilus* can reduce the pH value and increase the viscosity; *Lactobacillus plantarum* can improve the flavor, produce acid and active substances, and improve the taste of yogurt bites. The compound

microorganism shows a synergistic effect among its components. A variety of volatile flavor components formed during the fermentation process, such as acetic acid and butyric acid, can reflect a unique taste of fermentation, such that the resulting product has a flavor of yogurt and a unique aroma of oats, and is rich in nutrients and easy to be digested and absorbed. This measure can also improve the performance of oats, thus meeting people's needs for physiological health and balanced nutritional diet, and greatly increasing the added value of oat products.

[0038] In the present disclosure, the blended feed liquid has an oat solid content of 15%; and the jam has a volume of 20% of the blended feed liquid, and the freeze-dried oatmeal has a volume of 20% of the blended feed liquid. The blending can improve the taste and layering of the oat-based freeze-dried yogurt bites.

[0039] In the present disclosure, pre-freezing is conducted at preferably -35°C to -45°C for preferably 4 h to 6 h; and freeze-drying refers to vacuum freeze-drying including sublimation conducted at preferably -25°C to 0°C for 24 h (a sublimation temperature rises linearly from -25°C to 0°C within 24 h) and secondary vacuum drying conducted at 0°C to 35°C for 24 h (vacuum drying temperature rises linearly from 0°C to 35°C within 24 h). The vacuum freeze-drying can achieve crispy mouth feel, desirable palatability, and rich taste texture.

[0040] The present disclosure further provides oat-based freeze-dried yogurt bites prepared by the preparation method.

[0041] In the present disclosure, unless otherwise specified, all raw material components are commercially available products well known to persons skilled in the art.

[0042] The technical solutions of the present disclosure will be clearly and completely described below with reference to the examples of the present disclosure. Apparently, the described examples are merely a part rather than all of the examples of the present disclosure. All other embodiments obtained by those skilled in the art based on the embodiments of the present disclosure without creative efforts shall fall within the protection scope of the present disclosure.

[0043] In Examples 1 to 5 and Comparative Examples 1 to 6, the compound microorganism includes *Lactobacillus delbrueckii*, *Streptococcus thermophilus*, and *Lactobacillus plantarum* in a mass ratio of 1:1:1.

[0044] Example 1

[0045] Preparation of oat-based freeze-dried yogurt bites

[0046] A) Preparation of oat thick slurry: 3,500 g of oat core powder, 35 g of K₂HPO₄, 35 g of Ca₃(PO₄)₂, and 3.5 g of high-temperature amylase were mixed with 10,000 g of purified water, heated to 95°C, and subjected to wet-grinding for 20 min until the resulting product was fine and grain-free to give the oat thick slurry;

[0047] B) Enzymatic hydrolysis: the oat thick slurry was mixed with 1.75 g of α -amylase and 3.5

g of debittering enzyme, the pH value was adjusted to 6.80, and the enzymatic hydrolysis was conducted by stirring at 400 rpm and 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0048] C) Homogenization: 350 g of oat oil was added into the enzymatic hydrolyzate, stirred at 800 rpm for 5 min, and homogenization was conducted at 65°C and 20 MPa;

[0049] D) Pasteurization: the resulting feed liquid was heated to 95°C and then held for 5 min;

[0050] E) Fermentation: the mixed feed liquid obtained by pasteurization was cooled to 42°C and then inoculated with a compound microorganism, mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and a pH value of 4.55 for 6.5 h;

[0051] F) Blending: the obtained fermented feed liquid after constant-temperature fermentation was blended with 1.5 kg of freeze-dried oatmeal, 3 kg of mango jam, and 6.66 kg of water to allow for mixing evenly by stirring at 800 rpm to obtain a blended feed liquid;

[0052] G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -43°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at -25°C to 0°C for 24 h and vacuum drying at 0°C to 35°C for 24 h) in sequence, and then subjected to manual demolding to obtain a semi-finished product of oat-based freeze-dried yogurt bites; and

[0053] H) Chocolate coating: the semi-finished product was coated with natural cocoa butter chocolate at a thickness of 0.3 mm, and the chocolate was cooled to obtain the oat-based freeze-dried yogurt bites.

[0054] Example 2

[0055] Preparation of oat-based freeze-dried yogurt bites

[0056] A) Preparation of thick slurry: 3,500 g of oat core powder, 35 g of K_2HPO_4 , 35 g of $Ca_3(PO_4)_2$, and 3.5 g of high-temperature amylase were mixed with 10,000 g of purified water, heated to 97°C, and subjected to wet-grinding for 10 min until the resulting product was fine and grain-free to give the oat thick slurry;

[0057] B) Enzymatic hydrolysis: the oat thick slurry was mixed with 1.75 g of α -amylase and 3.5 g of debittering enzyme, the pH value was adjusted to 6.90, and the enzymatic hydrolysis was conducted by stirring at 500 rpm and 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0058] C) Homogenization: 350 g of oat oil was added into the enzymatic hydrolyzate, stirred at 800 rpm for 15min, and homogenization was conducted at 65°C and 18 MPa;

[0059] D) Pasteurization: the resulting feed liquid was heated to 95°C and then held for 15 min;

[0060] E) Fermentation: the mixed feed liquid obtained by pasteurization was cooled to 42°C and then inoculated with 6.75 g of a compound microorganism, mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and

a pH value of 4.55 for 4.5 h;

[0061] F) Blending: the obtained fermented feed liquid after constant-temperature fermentation was blended with 1.5 kg of freeze-dried oatmeal, 3 kg of blueberry jam, and 6.66 kg of water to allow for mixing evenly by stirring at 800 rpm to obtain a blended feed liquid;

[0062] G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -40°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at -25°C to 0°C for 24 h and vacuum drying at 0°C to 35°C for 24 h) in sequence and then subjected to manual demolding to obtain a semi-finished product of oat-based freeze-dried yogurt bites; and

[0063] H) Chocolate coating: the semi-finished product was coated with natural cocoa butter chocolate at a thickness of 0.3 mm, and the chocolate was cooled to obtain the oat-based freeze-dried yogurt bites.

[0064] Example 3

[0065] Preparation of oat-based freeze-dried yogurt bites

[0066] A) Preparation of thick slurry: 3,500 g of oat core powder, 35 g of K_2HPO_4 , 35 g of $Ca_3(PO_4)_2$, and 3.5 g of high-temperature amylase were mixed with 10,000 g of purified water, heated to 90°C, and subjected to wet-grinding for 10 min until the resulting product was fine and grain-free to give the oat thick slurry;

[0067] B) Enzymatic hydrolysis: the oat thick slurry was mixed with 1.75 g of α -amylase and 3.5 g of debittering enzyme, the pH value was adjusted to 6.90, and the enzymatic hydrolysis was conducted by stirring at 600 rpm and 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0068] C) Homogenization: 350 g of oat oil was added into the enzymatic hydrolyzate, stirred at 900 rpm for 15 min, and homogenization was conducted at 65°C and 22 MPa;

[0069] D) Pasteurization: the resulting feed liquid was heated to 95°C and then held for 15 min;

[0070] E) Fermentation: the mixed feed liquid obtained by pasteurization was cooled to 42°C and then inoculated with 6.75 g of a compound microorganism, mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and a pH value of 4.55 for 4 h;

[0071] F) Blending: the obtained fermented feed liquid after constant-temperature fermentation was blended with 1.5 kg of freeze-dried oatmeal, 3 kg of strawberry jam, and 6.66 kg of water to allow for mixing evenly by stirring at 800 rpm to obtain a blended feed liquid;

[0072] G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -40°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at -25°C to 0°C for 24 h and vacuum drying at 0°C to 35°C for 24 h) in sequence and then subjected to manual demolding to obtain a semi-finished product of oat-based

freeze-dried yogurt bites; and

[0073] H) Chocolate coating: the semi-finished product was coated with natural cocoa butter chocolate at a thickness of 0.5mm, and the chocolate was cooled to obtain the oat-based freeze-dried yogurt.

[0074] Example 4

[0075] A) Preparation of thick slurry: 3,500 g of oat core powder, 35 g of K_2HPO_4 , 35 g of $Ca_3(PO_4)_2$, and 3.5 g of high-temperature amylase were mixed with 10,000 g of purified water, heated to 90°C, and subjected to wet-grinding for 10 min until the resulting product was fine and grain-free to give the oat thick slurry;

[0076] B) Enzymatic hydrolysis: the oat thick slurry was mixed with 1.75 g of α -amylase and 3.5 g of debittering enzyme, the pH value was adjusted to 6.90, and the enzymatic hydrolysis was conducted by stirring at 600 rpm and 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0077] C) Homogenization: 350 g of oat oil was added into the enzymatic hydrolyzate, stirred at 900 rpm for 15 min, and homogenization was conducted at 65°C and 22 MPa;

[0078] D) Pasteurization: the resulting feed liquid was heated to 95°C and then held for 15 min;

[0079] E) Fermentation: the mixed feed liquid obtained by pasteurization was cooled to 42°C and then inoculated with 1.35 g of a compound microorganism, mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and a pH value of 4.55 for 15 h;

[0080] F) Blending: the obtained fermented feed liquid after constant-temperature fermentation was blended with 0.75kg of freeze-dried oatmeal, 1.5kg of strawberry jam, and 6.66 kg of water to allow for mixing evenly by stirring at 800 rpm to obtain a blended feed liquid;

[0081] G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -40°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at -25°C to 0°C for 24 h and vacuum drying at 0°C to 35°C for 24 h) in sequence and then subjected to manual demolding to obtain a semi-finished product of oat-based freeze-dried yogurt bites; and

[0082] H) Chocolate coating: the semi-finished product was coated with natural cocoa butter chocolate at a thickness of 1mm, and the chocolate was cooled to obtain the oat-based freeze-dried yogurt bites.

[0083] Example 5

[0084] A) Preparation of thick slurry: 3,500 g of oat core powder, 35 g of K_2HPO_4 , 35 g of $Ca_3(PO_4)_2$, and 3.5 g of high-temperature amylase were mixed with 10,000 g of purified water, heated to 80°C, and subjected to wet-grinding for 30 min until the resulting product was fine and grain-free to give the oat thick slurry;

[0085] B) Enzymatic hydrolysis: the oat thick slurry was mixed with 1.75 g of α -amylase and 3.5 g of debittering enzyme, the pH value was adjusted to 6.90, and the enzymatic hydrolysis was conducted by stirring at 600 rpm and 60°C for 1 h to obtain an enzymatic hydrolyzate;

[0086] C) Homogenization: 350 g of oat oil was added into the enzymatic hydrolyzate, stirred at 900 rpm for 15 min, and homogenization was conducted at 65°C and 22 MPa;

[0087] D) Pasteurization: the resulting feed liquid was heated to 95°C and then held for 15 min;

[0088] E) Fermentation: the mixed feed liquid obtained by pasteurization was cooled to 42°C and then inoculated with 1.35 g of a compound microorganism, mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and a pH value of 4.55 for 20 h;

[0089] F) Blending: the obtained fermented feed liquid after constant-temperature fermentation was blended with 0.75 kg of freeze-dried oatmeal and 1.5 kg of strawberry jam to allow for mixing evenly by stirring at 800 rpm to obtain a blended feed liquid;

[0090] G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -40°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at -25°C to 0°C for 24 h and vacuum drying at 0°C to 35°C for 24 h) in sequence and then subjected to manual demolding to obtain a semi-finished product of oat-based freeze-dried yogurt bites; and

[0091] H) Chocolate coating: the semi-finished product was coated with natural cocoa butter chocolate at a thickness of 0.1mm, and the chocolate was cooled to obtain the oat-based freeze-dried yogurt bites.

[0092] Comparative Example 1

[0093] In this comparative example, the specific implementation was the same as that in Example 1, except when preparing the oat thick slurry in step A) the raw materials were 3,500 g of oat core powder, 35 g of K_2HPO_4 , and 35 g of $Ca_3(PO_4)_2$.

[0094] Comparative Example 2

[0095] In this comparative example, the specific implementation was the same as that in Example 1, except that in step B) enzymatic hydrolysis was conducted as follows: the oat thick slurry was mixed with 5.25 g of debittering enzyme, the pH value was adjusted to 6.8, and the enzymatic hydrolysis was conducted by stirring at 400 rpm and 60°C for 1 h to obtain the enzymatic hydrolyzate.

[0096] Comparative Example 3

[0097] In this comparative example, the specific implementation was the same as that in Example 1, except that in step B) enzymatic hydrolysis was conducted as follows: the oat thick slurry was mixed with 5.25 g of α -amylase, the pH value was adjusted to 6.8, and the enzymatic hydrolysis

was conducted by stirring at 400 rpm and 60°C for 1 h to obtain the enzymatic hydrolyzate.

[0098] Comparative Example 4

[0099] In this comparative example, the specific implementation was the same as that in Example 1, except that in step E), fermentation was conducted as follows: the mixed feed liquid obtained by the pasteurization was cooled to 42°C and then inoculated with a commercially available ordinary yogurt leavening (Beijing Chuanxiu Technology Co., Ltd.), mixed and stirred to obtain a pre-fermented feed liquid, which was subjected to constant-temperature fermentation at 42°C and a pH value of 4.50 for 16 h.

[0100] Comparative Example 5

[0101] In this comparative example, a specific implementation was the same as that in Example 1, except that in step F) blending was conducted as follows: the obtained fermented feed liquid after constant-temperature fermentation was blended with 3 kg of mango jam to allow mixing evenly by stirring at 800 rpm to obtain a blended feed liquid.

[0102] Comparative Example 6

[0103] In this comparative example, a specific implementation was the same as that in Example 1, except that: G) Vacuum freeze-drying: the blended feed liquid was poured into a mold to allow pre-freezing at -43°C to -45°C for 6 h and freeze-drying in a vacuum freeze-drying chamber (including sublimation at 0°C to 45°C for 14 h and vacuum drying at 45°C for 12 h) in sequence and then subjected to manual demolding to obtain the semi-finished product of oat-based freeze-dried yogurt.

[0104] Experimental Example 1

[0105] The bitterness was measured for the oat thick slurry in Example 1, the enzymatic hydrolyzate obtained after enzymatic hydrolysis, and the enzymatic hydrolyzates obtained after enzymatic hydrolysis in Comparative Examples 2 to 3.

[0106] Specifically, 15 members in a group were trained for one month on the sensory description and classification of taste substances. The members were allowed to be familiar with various bitter substances. Sensory training for bitter taste generally involved a variety of bitter solutions, such as magnesium sulfate, salicylic acid, and caffeine solutions. The members who could not distinguish the intensity of bitter taste were eliminated. After training, a total of 10 people, 5 men and 5 women, formed a sensory evaluation group. The sensory tests were conducted in a specific laboratory. A 10-point scoring scale was adopted, including levels: 0-2, taste intensity was extremely weak (faintly discernible); 2-4, weak; 4-6, moderate; 6-8, strong; 8-10, extremely strong. The taste intensity was scored from 0 to 10, with 0 representing the absence of taste intensity and 10 representing a high intensity of the taste. During the sensory evaluation, samples were coded to reduce interference caused by subjective factors. All samples were randomly presented to sensory

evaluators and repeated three times. Throughout the entire evaluation, testers must rinse their mouths with pure water after the evaluation of one sample was completed and before the starting of another sample. In order to avoid temperature differences, all tested samples were kept at 25°C in a constant-temperature oven.

[0107] After testing, a bitterness sensory score of the oat thick slurry in Example 1 was 8, while a bitterness sensory score of the enzymatic hydrolysate after enzymatic hydrolysis was 0; a bitter sensory score of the enzymatic hydrolyzate in Comparative Example 2 was 2; and a bitter sensory score of the enzymatic hydrolyzate in Comparative Example 3 was 6. It could be seen that there was a synergistic effect between α -amylase and the debittering enzyme during the enzymatic hydrolysis of the present disclosure, and this effect could significantly reduce the bitterness in the oat thick slurry, thereby improving the taste of the yogurt bites.

[0108] Experimental Example 2

[0109] In the oat-based freeze-dried yogurt bites prepared in Examples 1 to 5 and Comparative Examples 1 to 6, the number of viable lactic acid bacteria, dietary fiber content, shelf life, and sensory score were used as evaluation indicators.

[0110] The number of viable lactic acid bacteria was counted according to a plate colony culture counting method in the national standard (GB4789.35-2016 National food safety standard -- Microbiological examination of food -- Examination of lactic acid bacteria).

[0111] The dietary fiber content was measured according to the Second Method in the national standard (GB/T22224-2008 - Determination of dietary fiber in foods -- Enzymatic gravimetric method and enzymatic gravimetric method -- Liquid chromatography).

[0112] The shelf life was measured according to the standard (T/CNFIA 001-2017 - General Guideline for Food Shelf Life).

[0113] The sensory evaluation was conducted by a scoring test method. A sensory evaluation team was composed of 10 professionally trained personnel; the scorers evaluated the oat-based freeze-dried yogurt cubes by four aspects: appearance (flat and smooth, no frost and sand phenomenon), taste and odor (obvious fruity taste, moderate sweetness and sourness, no peculiar smell), organization state (whether there were cavitation and fractures, and in glassy state), and mouth feel (crispness, tooth stickiness, fruity taste, and sweetness). The total score was 100 points, and the average score was taken as the final result. The evaluation criteria for the sensory evaluation are shown in Table 1.

[0114] Table 1 Sensory evaluation standards

[0115]

Item	Scoring standards	Score
Appearance	Flat and smooth, no frost or sand phenomenon	18-25

(total score 25)	Flat and slightly poor gloss, with frost or sand phenomenon	11-17
	Flat and slightly poor gloss, with slight frost or sand phenomenon	6-10
	Depressed and slightly poor gloss, with slight frost or sand phenomenon	0-5
Taste and odor (total score 25)	Obvious fruity taste, moderate sweetness and sourness, no peculiar smell	21-25
	Weak fruity taste, moderate sweetness and sourness, no peculiar smell	16-20
	Weak fruity taste, slightly excessive sweetness or sourness, no peculiar smell	11-15
	No fruity taste, slightly excessive sweetness or excessive sourness, no peculiar smell	6-10
	Peculiar smell	0-5
Organization state (total score 25)	No cavitation or fracture, and in glassy state	19-25
	Slight cavitation and fracture, and in glassy state	9-18
	Severe cavitation and brokenness, and in glassy state	0-8
Mouth feel (total score 25)	High crispness, no tooth stickiness, strong fruity taste, and moderate sweetness or sourness	18-25
	High crispness, slight tooth stickiness, weak fruity taste, and moderate sweetness or sourness	11-17
	Moderate crispness, slight tooth stickiness, weak fruity taste, and slightly excessive sweetness or sourness	6-10
	No crispness	0-5

[0116] The oat-based freeze-dried yogurt cube products prepared in Examples 1 to 5 and Comparative Examples 1 to 6 were stored at room temperature. Samples were taken regularly to determine the number of viable lactic acid bacteria, dietary fiber content, shelf life, and sensory scoring, so as to examine the changes in viable bacterial counts and sensory scoring of the oat-based freeze-dried yogurt cubes after being stored at room temperature for half a year. The specific test results are shown in Table 2.

[0117] Table 2 Quality of freeze-dried yogurt cubes treated with different treatments

[0118]

Group	Number of viable lactic acid bacteria (CFU/g)		Dietary fiber content (g/100 g)		Sensory scoring (point)		Shelf life (month)
	Day 1	6 months later	Day 1	6 months later	Day 1	6 months later	
Example1	5×10^{10}	6×10^9	10.20	10.20	95	95	12
Example2	4×10^{10}	5.8×10^8	11.11	11.10	92	91	12
Example3	5×10^{10}	6×10^9	9.77	9.80	98	98	12
Example 4	4×10^{10}	5.7×10^8	9.09	9.09	88	88	12

Example 5	4×10^{10}	6.3×10^9	8.99	8.88	87	88	12
Comparative Example 1	4×10^8	1×10^5	11.40	11.40	75	75	8
Comparative Example 2	6×10^9	7×10^8	10.90	10.92	83	83	12
Comparative Example 3	5×10^{10}	4×10^8	8.78	8.77	79	76	8
Comparative Example 4	6×10^7	8×10^4	10.35	10.35	81	79	6
Comparative Example 5	4×10^{10}	3×10^9	8.11	8.12	70	72	12
Comparative Example 6	2×10^4	1×10^2	9.71	9.80	20	0	0

[0119] As shown in the data of Table 2, compared with Comparative Examples 1 to 6, the oat-based freeze-dried yogurt bites prepared by the present disclosure could significantly increase the number of viable lactic acid bacteria and the dietary fiber content, significantly extend the shelf life at room temperature, and improve the taste of freeze-dried yogurt bites.

[0120] The above descriptions are merely preferred implementations of the present disclosure. It should be noted that a person of ordinary skill in the art may further make several improvements and modifications without departing from the principle of the present disclosure, but such improvements and modifications should be deemed as falling within the protection scope of the present disclosure.

WHAT IS CLAIMED IS:

1. A method for preparing oat-based freeze-dried yogurt bites, comprising the following steps:
 - A) preparing an oat thick slurry, comprising: mixing an oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, and high-temperature amylase with water, heating to $95^\circ C$, and wet-grinding to obtain the oat thick slurry;
 - B) conducting enzymatic hydrolysis, comprising: mixing the oat thick slurry with α -amylase and a debittering enzyme, adjusting a pH value of a resulting mixture to 6.80 to 7.00, and conducting the enzymatic hydrolysis at $60^\circ C$ for 1 h to obtain an enzymatic hydrolyzate;
 - C) conducting homogenization, comprising: adding an oat oil into the enzymatic hydrolyzate, stirring for 5 min, and conducting the homogenization at $60^\circ C$ to $70^\circ C$ and 20 MPa;
 - D) conducting pasteurization;
 - E) conducting fermentation: inoculating a compound microorganism into a feed liquid obtained after pasteurization, and conducting fermentation at $41^\circ C$ to $43^\circ C$ for 4 h to 6 h;
 - F) conducting blending, comprising: blending an obtained fermented feed liquid with freeze-dried oatmeal, jam, and water to obtain a blended feed liquid;
 - G) conducting vacuum freeze-drying, comprising: pouring the blended feed liquid into a mold to allow pre-freezing and freeze-drying in sequence to obtain a semi-finished product of the oat-based freeze-dried yogurt; and
 - H) coating with a chocolate, comprising: coating the semi-finished product with natural cocoa butter chocolate to obtain the oat-based freeze-dried yogurt.
2. The preparation method according to claim 1, wherein the oat core powder, K_2HPO_4 , $Ca_3(PO_4)_2$, high-temperature amylase, and the water are mixed in a mass ratio of 35:1:1:0.1:100.
3. The preparation method according to claim 1, wherein α -amylase, the debittering enzyme, and the oat core powder are mixed in a mass ratio of 0.05:0.1:100.
4. The preparation method according to claim 1, wherein the oat oil is added at 10% of a mass of the oat core powder.
5. The preparation method according to claim 1, wherein the pasteurization is conducted at $95^\circ C$ for 5 min.
6. The preparation method according to claim 1, wherein the compound microorganism

comprises *Lactobacillus delbrueckii*, *Streptococcus thermophilus*, and *Lactobacillus plantarum* in a mass ratio of 1:1:1, and is inoculated at in inoculum size of 0.05%.

7. The preparation method according to claim 1, wherein the blended feed liquid has an oat solid content of 15%; and the jam has a volume of 20% of the blended feed liquid, and the freeze-dried oatmeal has a volume of 20% of the blended feed liquid.

8. The preparation method according to claim 1, wherein the pre-freezing is conducted at -35°C to -45°C for 4 h to 6 h; and the freeze-drying refers to vacuum freeze-drying comprising sublimation conducted at -25°C to 0°C for 24 h and vacuum drying conducted at 0°C to 35°C for 24 h.

9. Oat-based freeze-dried yogurt bites prepared by the preparation method according to any one of claims 1 to 8.