(Temperature in pressurized heating treatment)

The temperature in the pressurized heating treatment varies depending on the pressure and is a temperature exceeding 100°C because of the pressurized state, but depending on embodiments, the temperature may be 120°C or higher, 130°C or higher, 140°C or higher, 150°C or higher, 160°C or higher, or 170°C or higher. Although the upper limit of the temperature is not set, the temperature is usually 250°C or lower.

[0031]

(Heating time for pressurized heating treatment)

The heating time of the pressurized heating treatment can be appropriately set in consideration of the combination with the heating temperature so that the enzyme-immobilization carrier has a desired quality, but a short time is preferable, and the heating time may be 1 minute or shorter, 30 seconds or shorter, 20 seconds or shorter, 10 seconds or shorter, 5 seconds or shorter, 2 seconds or shorter, 1 second or shorter, and particularly 0.5 seconds or shorter, or 0.3 seconds or shorter. In addition, the heating time may be 0.00001 seconds or longer, 0.0001 seconds or longer, or 0.001 seconds or longer. Furthermore, as one preferable embodiment, a range of 0.00001 to 2 seconds, 0.0001 to 1 second, or 0.001 to 0.5 seconds may be selected.

[0032]

(Direct heating method)

Heating methods for the pressurized heating treatment are broadly classified into a direct heating method and an indirect heating method. A preferable embodiment for obtaining the enzyme-immobilization carrier of the present invention adopts a direct heating method using steam. Examples of powder heat treatment apparatuses capable of performing such pressurized heating treatment include “KPU” (OKAWARA MFG. CO., LTD.), “SKS-50” (SEISHIN ENTERPRISE Co., Ltd.), “Sonic Stera” (manufactured by Fujiwara Techno-Art Co., Ltd.), which are airflow type powder sterilizers, and improved types of them. As described above, by

the direct heating method using steam such as superheated steam, the powder of the powdered plant protein material is directly exposed to steam and subjected to the pressurized heating treatment, and thereby the powdered plant protein material can be aggregated and granulated.

[0033]

(Vertical type)

Furthermore, in the present invention, it is preferable to perform the pressurized heating treatment by the direct heating method using steam while dropping the powdered plant protein material in a powdered state in a vertically direction in the pressurized heating treatment by the direct heating method. A pressurized heating device for implementing such a heating method is preferably a device having a heating space of a closed system in which a powder introduced into the device can be dropped in a vertical direction, and having a mechanism for bringing the powder into contact with steam in a pressurized state during dropping of the powder in the space. In the present invention, such a pressurized heating device is called a “vertical type.” As an aspect of the vertical type, a sterilizer for powders and granules as disclosed in Patent Literature 6 can be applied as the pressurized heating device, and specifically, commercially available “Sonic Stera” (manufactured by Fujiwara Techno-Art Co., Ltd.) can be used.

Accordingly, the NSI of the powdered plant protein material can be efficiently reduced to a desired range, making it possible to produce the enzyme-immobilization carrier that has higher water absorbability and is suitable for immobilizing enzymes.

[0034]

(Horizontal type)

On the other hand, when the powder is heated using a highly water-soluble plant protein material as a raw material and using a pressurized heating device of a so-called “horizontal type” in which a heating space of a closed system that is pressurized and heated by steam is disposed in a horizontal direction, the powder may stick to the inside of the device, making the efficiency

A treated product, which was obtained by the pressurized heating treatment with a heating pressure of 0.2 MPa and a heating time of 0.2 seconds, was passed through a 20 M (850 μm) sieve, and the fraction that remained on a 100 M (150 μm) sieve was classified to obtain a pressurized heating-treated product A. The pressurized heating-treated product A had a bulk specific gravity of 0.26 g/cm^3, an NSI of 64.8, a water supply ratio of 7.5, and an oil absorption ratio of 2.5 (which are shown in Table 1).

[0041]

(Pressurized heating-treated products B to D)

The pressurized heating treatment was performed at a heating pressure of 0.6 MPa and a heating time of 0.2 seconds using the same powdered plant protein material and pressurized heating device as in the pressurized heating-treated product A. This treated product was passed through a 20 M (850 μm) sieve, and the fraction that remained on a 100 M (150 μm) sieve was classified to obtain a pressurized heating-treated product B.

Furthermore, the treated product was passed through a 3.5 M (5.6 mm) sieve, and the fraction that remained on a 20 M (850 μm) sieve was classified to obtain a pressurized heating-treated product C having a relatively large particle size.

Furthermore, the fraction that had passed through a 100 M (150 μm) sieve was classified to obtain a pressurized heating-treated product D having a relatively small particle size.

Table 1 shows the bulk specific gravity, the NSI, the water supply ratio, and the oil absorption ratio of the pressurized heating-treated products B to D thus obtained.

[0042]

(Examples 1 to 4)

Immobilized enzymes of Examples 1 to 4 were respectively prepared according to the formulations shown in Table 2 using the pressurized heating-treated products A to D as enzyme-immobilization carriers. A preparation method was performed according to a “○