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(54) **Title**: FOOD STERILIZATION AND PRESERVATION METHOD

(54) 発明の名称 : 食品の殺菌・保存方法

(57) **Abstract**: The present invention addresses the problem of providing a food sterilization and preservation method whereby a mycotoxin can be eliminated from a food and the recurrence of the mycotoxin can be prevented even during prolonged preservation. For the purpose of solving the problem, provided is a method for eliminating a mycotoxin, said method comprising: a water vapor plasma irradiation step for irradiating water vapor plasma to a food that is contaminated with the mycotoxin; and a step for applying a powder of a calcined natural calcium material to the food that has been treated in the water vapor plasma irradiation step.

(57) 要約:　食品からマイコトキシンを除去し、かつ、長期間保存しても、再度マイコトキシンの発生を防ぐ、食品の殺菌・保存方法を提供することを課題とする。マイコトキシンが混在する食品に対し水蒸気プラズマを照射する水蒸気プラズマ照射工程、及び前記水蒸気プラズマ照射工程を経た食品に対し、天然カルシウム素材焼成粉末を適用する工程、を含む、マイコトキシン除去方法により課題を解決する。

SPECIFICATION

THE FOOD STERILIZATION AND PRESERVATION METHOD

FIELD OF THE INVENTION

[0001]

The present invention relates to a food sterilization and preservation method and particularly to a food sterilization and preservation method using water vapor plasma and a calcined powder of a natural calcium-rich material.

BACKGROUND OF THE INVENTION

[0002]

Mold usually grows on food stored for a long time period under high temperature/high humidity conditions. Some types of the growing mold produce fungal toxins such as mycotoxin. Thus, a fungal toxin, such as mycotoxin, sometimes adheres to a food material particularly produced in a region where temperature and humidity are high enough for mold to grow and there are plenty of examples in which import of such a food material is restricted under the Food Sanitation Law.

[0003]

Mycotoxin, which is known to be a class of fungal toxin produced by mold, is a general term for any substance which causes an acute or chronic physiological or pathological disorder to human, live stocks and the like and 300 or more kinds of mycotoxins have been currently reported.

[0004]

A method to remove a fungal toxin, mycotoxin, has been studied. For example, Patent Document 1 proposes a method of decontaminating a contaminated mycotoxin or preventing contamination of a mycotoxin by applying a composition containing eugenol or clove oil to a storage house.

Patent Document 2 proposes a feed additive material for removal of mycotoxin, which contains mineralized coral prepared by heating, crushing and activating hermatypic coral.

However, when the inventors examined the methods in Patent Documents 1 and 2, they showed a transient mycotoxin-removing effect but new mold colonies developed and thus a mycotoxin was produced again in cases where a food material was stored for a long time period. Therefore, these methods are insufficient for long-term food preservation.

[0005]

Furthermore, in the context of food preservation, disclosed is a method to keep cut vegetables fresh by soaking them in a solution of a calcined product of a natural calcium-rich material in water (see, Patent Document 3). However, the maximum storage life was one week in this method and an alternative countermeasure must be examined in cases where longer preservation was required.

[0006]

On the other hand, the inventors have independently developed a water vapor plasma generating apparatus, a technology to kill bacteria such as *Escherichia coli* and spore-bearing bacteria with the water vapor plasma, and a

technology to subject an oily component-containing material to an antioxidative treatment with the water vapor plasma (see, Patent Document 4).

PRIOR ART

Patent Documents

[0007]

[Patent Document 1] Japanese Patent Application Publication No. 2007-325584

[Patent Document 2] Japanese Patent Application Publication No. 2007-174926

[Patent Document 3] Japanese Patent Application Publication No. 2009-278885

[Patent Document 4] WO2010/016347 International Publication brochure

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0008]

The inventors have found that the water vapor plasma described in Patent Document 4 is effective in removal of aflatoxin, which is a kind of mycotoxin and whose carcinogenicity is considered to be particularly high, and have applied for a patent (Japanese Patent Application No. 2010-234566).

On the other hand, a mycotoxin is removed from a food by the method in Patent Document 4 but anything related to

long-term food preservation is not studied in the document.

An object of the present invention is to provide a food sterilization and preservation method, with which a mycotoxin is removed from a food and growth of mold is suppressed and re-generation of fungal toxins can be prevented even after a long storage period of 1 month or longer.

MEANS FOR SOLVING THE PROBLEMS

[0009]

The inventors studied intensively to resolve the above-described problem and eventually found that regrowth of mold even after a long storage period of 1 month or longer could be prevented by irradiating a food with water vapor plasma to remove fungal toxins and subsequently applying a calcined powder of a natural calcium-rich material to the food, and thereby completed the present invention.

[0010]

That is, the present invention is as follows:

[1] a food sterilization and preservation method comprising a water vapor plasma irradiation step of irradiating a food with water vapor plasma and a step of applying a calcined powder of a natural calcium-rich material to the food which has undergone the water vapor plasma irradiation step;

[2] the food sterilization and preservation method according to [1], wherein said water vapor plasma is at not less than 250°C and not more than 850°C;

[3] the food sterilization and preservation method according

to [1] or [2], wherein the irradiation time of said water vapor plasma is not less than 3 seconds and not more than 120 seconds;

[4] the food sterilization and preservation method according to any one of [1] to [3] wherein, said plasma is generated by a water vapor plasma generating apparatus comprising: a conductive object to be heated which discharges inflow water vapor as water vapor plasma; and a coil which wraps around said object to be heated and is supplied with a high-frequency currentto heat said object to be heated by electromagnetic induction, wherein said object to be heated comprises a plurality of members to be heated provided continuously and integrally from an inlet side of the water vapor toward an outlet side of the water vapor plasma, wherein through-holes which gradually decrease in number as disposed positions thereof shift from the inlet side of the water vapor toward the outlet side of the water vapor plasma, and concave portions which constitute passing regions for the water vapor together with said through-holes on at least one of surfaces opposed to each other are formed in said plurality of members to be heated, and wherein said coil comprises a hollow tube at a center of its wiring body and said hollow tube is a flow path where a coolant flows;

[5] the food sterilization and preservation method according to any one of [1] to [4], wherein said calcined powder of the natural calcium-rich material is applied at a ratio of 0.001 to 2% by weight;

[6] the food sterilization and preservation method according

to any one of [1] to [5], wherein said calcined powder of the natural calcium-rich material is obtained by calcination at a calcination temperature of 1,000°C or more;

[7] a food production method comprising processing a food by the food sterilization and preservation method according to any one of [1] to [6].

EFFECT OF THE INVENTION

[0011]

The food sterilization and preservation method of the present invention can prevent regrowth of mold and re-generation of fungal toxins produced by the mold even though food is stored for a long time period of 1 month or longer. Consequently, safe food can be provided even after long-term storage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 shows an example of a water vapor plasma generating apparatus used in the present invention.

FIG. 2(A) shows the side view of one exemplary disk member to be heated located at the end into which water vapor from a water vapor boiler flows and (B) shows the front view of the disk member to be heated indicated in (A).

FIG. 3(A) shows the side view of one exemplary disk member to be heated located at the end from which water vapor is discharged

and (B) shows the front view of the disk member to be heated indicated in (A).

FIG. 4(A) shows the side view of a treatment chamber, in which the water vapor plasma of the present invention is irradiated, and (B) shows the cross-section view of the treatment house indicated in (A) taken in the direction from an arrow B to another arrow B.

FIG. 5(A) shows the side view of a treatment chamber, in which the water vapor plasma of the present invention is irradiated, and (B) shows the cross-section view of the treatment house indicated in (A) taken in the direction from an arrow B to another arrow B.

FIG. 6 shows results of a storage test of peanut (for 4 months) performed in Examples (pictures serve as drawings).

FIG. 7 shows results of a storage test of peanut (for 595 days) performed in Examples (pictures serve as drawings).

BEST MODE FOR CARRYING OUT THE INVENTION

[0013]

The food sterilization and preservation method of the present invention comprises:

i) a water vapor plasma irradiation step in which a food material is irradiated with water vapor plasma, and

ii) a step of applying a calcined powder of a natural calcium-rich material to the food material which has undergone the water vapor plasma irradiation step.

[0014]

Growth of mold results in production of fungal toxins as a secondary metabolite thereof and mycotoxin is a representative fungal toxin. The produced mycotoxin persists even though a mycotoxin-producing fungal strain is killed. Furthermore, mycotoxin is hardly thermally decomposed and is not degraded by heating at the temperature used in food processing and the like or by environmental change and therefore removal of mycotoxin is difficult. Three hundred or more kinds of mycotoxins are known and representative examples thereof include aflatoxin, ochratoxin, citrinin, trichothecene, patulin, and the like.

[0015]

The present invention enables removal of fungal toxins produced by mold, such as mycotoxin, and preservation in which further production of these fungal toxins is prevented. Examples of food to which the present invention is applied shall include feed eaten by live stocks and the like, in addition to food eaten by human beings, such as crops, for example, soybean, wheat, peanut, corn, coffee bean and the like; and meat, for example, beef, poultry, pork, and the like.

<Water Vapor Plasma Irradiation Step in Which Water Vapor Plasma Is Irradiated>

[0016]

The water vapor plasma irradiation step is a step in which a food is irradiated with water vapor plasma.

The term "plasma" refers to a situation where gas is ionized. In the water vapor plasma of the present invention, positively and negatively charged particles move at high speed and a large Coulomb force is established between the charged particles and therefore the charged particles have more energy than particles in electrically neutral gas such as heated water vapor. This allows atoms and molecules generated through cleavage of bonds by high energy particles to exist in gas phase and the presence of such atoms and molecules allows water vapor plasma to have quite strong oxidation power and/or reduction power.

[0017]

Such water vapor plasma is not restricted by generation technique and/or generating apparatus therefor but the water vapor plasma generated by high-frequency induction heating is preferable and the output power of the above-described high-frequency currentis preferably not less than 30 kW and not more than 1,000 kW for stable supply of the water vapor plasma. Furthermore, the frequency of the wave is preferably not less than 5 kHz and not more than 40 kHz.

[0018]

Furthermore, the lower limit temperature of the above-described water vapor plasma is preferably not less than 250°C, more preferably not less than 300°C, and still more preferably not less than 350°C. On the other hand, the lower limit temperature is preferably not more than 850°C, more preferably not more than 700°C, and still more preferably not

more than 600°C.

[0019]

Differing from oxygen plasma, the water vapor plasma used in the present invention employs water vapor and therefore the temperature of the plasma is at least 100°C or more. Furthermore, in case of high temperature plasma (200°C to 600°C) utilizing oxygen plasma, a subject to be treated is damaged and therefore exposure time is necessarily restricted to 1 second or less. However, in the treatment method using the water vapor plasma of the present invention, a subject to be treated is only very slightly damaged and therefore irradiation time can be usually not less than 3 seconds and not more than 120 seconds. Irradiation time is preferably not less than 5 seconds, and more preferably not less than 10 seconds. Furthermore, irradiation time is preferably not more than 90 seconds, more preferably not more than 75 seconds, and still more preferably not more than 60 seconds.

[0020]

A water vapor plasma treatment apparatus, for example, as described below can be employed to perform the above-described irradiation with water vapor plasma. The apparatus will be described below by means of drawings.

[0021]

As illustrated in FIG. 1, the plasma treatment apparatus 1 comprises the water vapor plasma generating apparatus 10, a treatment chamber 20, an inverter 30, a water vapor boiler 40, and a coolant tank 50.

[0022]

The water vapor plasma generating apparatus 10 is an apparatus for generating water vapor plasma that is applied to an object to be treated such as a food. The water vapor plasma generating apparatus 10 comprises a object to be heated 11, a coil 12 for heating the object to be heated 11 by electromagnetic induction, a heat insulator 13 for covering the object to be heated 11 for thermal insulation, a water vapor inlet portion 71 for the water vapor generated by the water vapor boiler 40 to flow into the object to be heated 11, a water vapor plasma discharging portion 72 in order to discharge the water vapor plasma generated from the object to be heated 11, and a jet nozzle 73 to eject the water vapor plasma into the treatment chamber 20. Note that the water vapor plasma generating apparatus 10 is protected by an insulating cover made of a plastic material (not shown).

[0023]

The object to be heated 11 is heated by electromagnetic induction with the coil 12 which is supplied with a high-frequency current from the inverter 30. The object to be heated 11 preferably consists of a plurality of disk members to be heated 11a having conductivity. The object to be heated is not necessarily a disk member, but is preferred to be a disk member in view of efficiency in electromagnetic induction heating of the object to be heated with the coil. The disk object to be heated 11a is made of a conductive material, for example, a metal such as iron, stainless steel, nickel, or

titanium, or a conductive ceramic material such as carbon ceramic.

[0024]

The plurality of disk members to be heated 11a are provided continuously and integrally from an inlet side of the water vapor from the water vapor boiler 40 toward the outlet side of the water vapor plasma, as illustrated in FIG. 1. In addition, a plurality of through-holes 111a is formed in the disk object to be heated 11a as illustrated in FIGS. 2 and 3, and a plurality of grooves 112a is formed on each of the front surface and the back surface of the disk object to be heated 11a. FIG. 2 illustrates the disk object to be heated 11a that is disposed at an extremity of the side into which the water vapor flows from the water vapor boiler 40, and FIG. 3 illustrates the disk object to be heated 11a that is disposed at an extremity of the side from which the water vapor plasma is discharged.

[0025]

The through-holes 111a are formed in the disk object to be heated 11a so as gradually to decrease in the number as disposed positions thereof shift from the inlet side of the water vapor from the water vapor boiler 40 toward the outlet side of the water vapor plasma. For instance, the number of the through-holes 111a formed in the disk object to be heated 11a disposed at an extremity of the side into which the water vapor flows from the water vapor boiler 40 can be 100, and the number of the through-holes 111a formed in the disk object to be heated 11a disposed at an extremity of the side from which

the water vapor plasma is discharged can be 10. Note that the number of the members to be heated which are provided continuously and integrally is not specifically limited, but it is determined in accordance with an output power and a frequency of the high-frequency current, a type and a quantity of the object to be treated, and the like.

[0026]

The grooves 112a on the disk object to be heated 11a are formed irregularly, and hence spaces 113a are formed between the plurality of disk members to be heated 11a. The water vapor flowing into the object to be heated 11 is restricted to be able to pass only through areas of the spaces 113a and the through-holes 111a, in addition the number of the through-holes 111a gradually decreases in the number while going toward the side from which the water vapor is discharged as the water vapor plasma, and therefore the passable area is restricted gradually.

[0027]

The water vapor flowing into the object to be heated 11 becomes a temperature of 250 degrees centigrade or higher by the object to be heated 11 that was heated by electromagnetic induction, and passes only through the through-holes 111a which gradually decreases in number toward the outlet side and the spaces 113a, so that the passing region is gradually restricted toward the outlet side. Therefore, the water vapor expands gradually while colliding against the disk members to be heated 11a, and the force to pass through the through-holes is

gradually increased. As a result, the water vapor becomes an ionized state and is discharged as water vapor plasma. Note that despite the passing region being restricted gradually toward the outlet side, the water vapor flowing in does not flow backward. In addition, the water vapor flowing into the object to be heated 11 is heated by electromagnetic induction, but the water vapor plasma is apt not to be generated stably if the heated water vapor is lower than 250 degrees centigrade.

[0028]

In the discharged water vapor plasma, positively and negatively charged particles move around at high speed, and a large Coulomb force is exerted between the charged particles, so that the kinetic energy of the particles becomes much larger than that of electrically neutral gas such as a superheated vapor. For example, because highly active neutral atoms and molecules such as hydrogen atoms, oxygen atoms, or OH radicals in the water vapor, whose bonds were cut off by the high energy particles, exist in the plasma, the water vapor plasma has a high disinfecting and sterilizing ability, and further an antioxidative function.

[0029]

The coil 12 has a hollow tube in the center of its wiring body, and coolant is supplied to the hollow tube via an inlet hose 51 so that heating of the coil 12 itself can be prevented and that the fluid passing through the object to be heated 11 can have a stable temperature. If the coolant is not supplied to the coil 12, temperature of the fluid passing through the

object to be heated 11 becomes unstable, so that water vapor plasma cannot be generated.

[0030]

The inverter 30 is an apparatus for applying high-frequency induction heating to the object to be heated 11 via the coil 12. A high-frequency inverter is used as the inverter 30, and it is preferred that an output power of the high-frequency current be approximately 30 to 500 kW and a frequency thereof be 10 to 20 kHz. Note that the inverter 30 is connected electrically to the coil 12 via a conductive wire 31.

The output power of the high-frequency current is 30 kW or higher so that the water vapor plasma can be generated stably by the water vapor plasma generating apparatus 10. Note that the inlet hose 51 of the coolant from the coolant tank 50 also passes through the inside of the inverter 30, so that a semiconductor device and the like disposed inside the inverter 30 are cooled.

[0031]

The water vapor boiler 40 is connected to the water vapor plasma generating apparatus 10 by a conduit 60 via a water vapor inlet portion 71. Note that the conduit 60 is provided with an on-off valve 61 and a check valve 62 for the water vapor generated by the water vapor boiler 40. The amount of water vapor flowing from the water vapor boiler 40 into the water vapor plasma generating apparatus 10 can be appropriately set according to the capacity of the apparatus and is usually from

10 kg/h to 800 kg/h, preferably from 20 kg/h to 200 kg/h, and more preferably from 30 kg/h to 100 kg/h.

[0032]

The coolant tank 50 comprises an inlet hose 51 for the coolant to flow into one end of the wiring body of the coil 12 and for cooling the inside of the inverter 30, and an outlet hose 52 for the coolant to flow out from the other end of the wiring body of the coil 12.

[0033]

The treatment chamber 20 comprises a cylindrical main body 21, an input port 22 for the object to be treated which is disposed above the main body, an input adjusting portion 23 for the object to be treated, an opening for water vapor plasma application 24 formed in the side wall of the main body 21, and an installation table 25 for supporting the main body 21. The opening for water vapor plasma application 24 is connected to a water vapor plasma leading tube 74.

[0034]

Design of the treatment chamber 20 can be modified appropriately in accordance with a type of the object to be treated. It may be used a treatment chamber comprising a treatment chamber main body, a net portion having a laterally cylindrical shape which houses an object to be treated and in turn is housed in the treatment chamber, a rotating object which comprises a screw impeller fixed to the net portion for stirring the object to be treated and is housed in the treatment chamber, a motor for rotating the rotating object, and a water vapor

plasma supplying portion for supplying water vapor plasma into the treatment chamber.

[0035]

With reference to FIG. 4 for description, a treatment chamber 211 comprises a net-like rotating object 212 housing an object to be treated such as a food, which is housed in the treatment chamber, a water vapor plasma supplying portion 213 for supplying water vapor plasma into the treatment chamber, a motor 214 for rotating the net-like rotating object 212, a gear portion 215 (215a and 215b) for fixing the gear portion 215 and transmitting a driving force of the motor 214 to the net-like rotating object 212, an input portion 216 for supplying the object to be treated to the net-like rotating object 212, and a guiding plate 219 for taking out the object to be treated after the sterilization and disinfection, which is disposed on the opposite side to the input portion 216.

[0036]

The rotating object 212 is for stirring the object to be treated that was housed during the antioxidative treatment. The rotating object 212 consists of a net portion 212a, a screw impeller 212b, stirring flat plates 212c, and fixing portions 212d. The net portion 212a consists of a laterally cylindrical net. A mesh size of the net portion 212a is modified in accordance with a size of the object to be treated that is housed. One end of the net portion 212a comprises an input opening 212e from which the object to be treated is supplied, and the other end of the net portion 212a comprises an output opening 212f

from which the object to be treated is taken out.

[0037]

The screw impeller 212b stirs the object to be treated that is housed in the net portion 212a. The screw impeller 212b is formed continuously in a helical shape and is capable of rotating about the center axis of the net portion 212a as a rotation axis. Further, the thickness of the screw impeller 212b is changed in accordance with a type of the object to be treated. Therefore, the thickness of the rotating object 212 is changed in accordance with a type of the object to be treated. Thus, as to the rotating object 212, the mesh size of the net portion 212a and the thickness of the screw impeller 212b can be adjusted in accordance with a type of the object to be treated.

[0038]

The stirring flat plates 212c are housed in the net portion 212a together with the screw impeller 212b so as to stir the object to be treated. Note that the stirring flat plates 212c are used, for example, if the object to be treated is a noodle or the like, so that the rotation speed of the rotating object 12 is slow. The stirring flat plates 212c are fixed to an inner peripheral surface of the net portion 212a at a constant pitch along the extending direction of the net portion 212a.

[0039]

A pair of the fixing portions 212d is for housing and fixing the rotating object 212 in the treatment chamber 212 via the gear portion 215 detachably. The fixing portion 212d is formed in a ring-like shape. The pair of fixing portions 212d

is fixed to both ends of the net portion 212a, and screw holes (not shown) for engaging bolts 217 are formed in the same. Each of the fixing portions 212d is fixed the pair of gear portions 212 disposed in the treatment chamber 211 by engaging the bolts 217 with the screw holes.

[0040]

The water vapor plasma supplying portion 213 is connected to the water vapor plasma generating apparatus and comprises a bifurcated tube. The water vapor plasma supplying portion 213 is disposed above the rotating object 212 in the treatment chamber 211. A plurality of holes 213a (see FIG. 4(b)) for discharging the water vapor plasma are formed in the water vapor plasma supplying portion 213.

[0041]

A gear wheel 218a is fixed to a rotation shaft 214a of the motor 214 in the treatment chamber 211. The gear wheel 218a engages with a gear portion 215a on the input portion 216 side. Therefore, the driving force of the motor 214 is transmitted to the rotating object 212 via the gear wheel 218a and the gear portion 215a. A gear wheel 218b is disposed at a position in parallel to the gear wheel 218a at the lower portion in the treatment chamber 211. The gear wheel 218b also engages with the gear portion 215a on the input portion 216 side, so as to assist and support the rotation of the gear portion 215a. In addition, a bearing 220 is disposed in the treatment chamber 211 so as to guide the inner surface of the gear portion 215a for preventing the rotating object 212 from floating.

[0042]

In addition, the gear portion 215b on the guiding plate 219 side also engages with gear wheels 218c and 218d provided in parallel inside the treatment chamber 211. By the gear wheels 218c and 218d, the gear portion 215b is supported and rotates smoothly.

[0043]

In addition, the treatment chamber may have a structure as illustrated in FIG. 5. Hereinafter, with reference to FIG. 5, only the part different from that illustrated in FIG. 4 is described.

[0044]

In the treatment chamber 211, the rotating object 212 comprises a rotation shaft 222g. The rotation shaft 222g is formed integrally with a screw impeller 222b that is formed continuously in a helical shape. The rotation shaft 222g is detachably connected to the rotation shaft of the motor (not shown) and is supposed outside the treatment chamber 211 so as to be rotatable. Note that the rotating object 212 does not comprises the stirring flat plate 212c of the embodiment illustrated in FIG. 4.

[0045]

In this embodiment, the rotation shaft 222g of the rotating object 212 is driven by the motor to rotate, so that the rotating object 212 is rotated. The rotating object 212 can be rotated with the structure that is easier than that of the first embodiment, and the same treatment as the embodiment

in FIG. 4 can be performed.

[0046]

The object to be treated is supplied into the treatment chamber described above, and the water vapor plasma generated by the water vapor plasma generating apparatus is applied to the object to be treated so that a mycotoxin which are existed on the object can be removed.

<A Step of Applying A Calcined Powder of A Natural Calcium-Rich Material to a Food Which Has Undergone the Water Vapor Plasma Irradiation Step>

[0047]

In the present invention, the next step is to apply a calcined powder of a natural calcium-rich material to a food material which has undergone the water vapor plasma irradiation step.

Examples of a natural calcium-rich material used in the present invention generally include naturally occurring materials such as shells of shellfishes, for example, scallop, oyster, abalone, clam, pearl oyster, hen clam, and the like; coral, nacre, eggshell, and the like, which materials contain a water-insoluble calcium compound(s) such as calcium carbonate or various types of calcium phosphate. In the present invention, a calcined product prepared by calcination of such a material to yield mainly calcium oxide is used.

[0048]

In the present invention, a method of applying a calcined

powder of the natural calcium-rich material to a food material is not particularly restricted but the powder may be directly applied by sprinkling it on a food material or may be applied as a solution of the powder dispersed or dissolved in a dispersion medium.

In cases where the powder is directly sprinkled on food, the calcined powder of the natural calcium-rich material is applied to a food material usually at a ratio of not less than 0.001% by weight, preferably not less than 0.01% by weight, more preferably not less than 0.05 g by weight, or not more than 2% by weight, preferably not more than 1% by weight, and more preferably not more than 0.5% by weight. When the amount of the powder applied to a food material is large, the powder is visible and therefore the appearance of the food is sometimes bad.

In cases where the powder is directly sprinkled on food, the powder and a food material are preferably blended after sprinkling the powder over the food material, such that the powder is applied to the entire body of the food material. The blending procedure is not particularly restricted but may be a procedure in which the powder is added to a bag containing a food material and subsequently the bag is shaken from right to left or up and down.

[0049]

Examples of a solvent used to disperse or dissolve the powder include water. In this case, the volume of the solution applied to a food material should be adjusted such that the

above-described amount of the powder is applied to a food material. When too much water is added, mold grows easily and therefore water in as small a volume as possible is preferred to disperse the powder. Furthermore, the prepared solution may be applied by spraying with a spray gun and the like.

[0050]

The calcined powder of the present invention can be obtained by burning any of the above-described natural calcium-rich materials with a suitable method among conventionally used calcination methods and crushing the resulted calcined product. Examples of a baking furnace used in calcination include, for example, electric furnace. Calcination is usually performed at 600°C to 1,500°C, but it is preferably performed in the present invention at not less than 1,000°C in the context of the potential to suppress generation of mycotoxin. The upper limit is preferably not more than 1,300°C. This is because calcination at this range of temperature provides a sufficient inhibitory effect on generation of mycotoxin and also allows this effect to last long.

[0051]

The above-described calcined product of the natural calcium-rich material is crushed after calcination to obtain a powder using a primary crusher such as cutter mill, hammer mill, roller mill or crusher; and a pulverizer such as ball mill, jet mill or cyclone mill. In the present invention, the particle diameter of the powder particle is not particularly

restricted but the volume average diameter is preferably around 1 to 60 μm.

[0052]

According to the food sterilization and preservation method of the present invention, it can prevent regrowth of mold as well as also successfully exerts an effect on food product pests, in which the food product pests are kept away from food materials during storage.

Examples of food product pests include, especially in cases where cereal is the intended food, *Paralispa gularis*, *Oryzaephilus mercator*, *Alphitobius diaperinus*, *Corcyra cephalonica*, *Carpophilus dimidiatus*, *Cryptolestes pusillus*, *Pyralis farinalis*, *Tribolium freemani* Hinton, *Neatus ventralis*, *Sitophilus granarius*, *Sitophilus zeamais* Motschulsky, *Tenebroides mauritanicus*, *Tribolium castaneum*, *Sitophilus oryzae*, *Rhyzopertha dominica*, *Carpophilus pilosellus* Motschulsky, *Tenebrio obscurus* Fabricius, *Aglossa dimidiata*, *Stegobium paniceum*, *Cadra cautella*, *Lasioderma serricorne*, *Dinoderus minutus*, *Tenebrio molitor* Linnaeus, *Oryzaephilus surinamensis*, *Plodia interpunctella*, *Sitotroga cerealella*, *Trogoderma granarium*, *Alphitobius laevigatus*, *Tribolium confusum* Jacquelin du Val, *Liposcelis bostrychophila* Badonnel, *Alphitophagus bifasciatus*, *Lophocateres pusillus*, and the like.

Furthermore, examples of food product pests include, especially in cases where bean is the intended food, *Callosobruchus analis*, *Callosobruchus chinensis*,

Acanthoscelides obtectus, *Plodia interpunctella*, *Trogoderma granarium*, *Callosobruchus maculatus*, and the like.

Furthermore, examples of food product pests include, especially in cases where dried food is the intended food, *Trogoderma varium*, *Attagenus fasciatus*, *Corcyra cephalonica*, *Carpophilus dimidiatus*, *Pyralis farinalis*, *Sitophilus zeamais* Motschulsky, *Sitophilus oryzae*, Anthrenus nipponensis, *Stegobium paniceum*, *Cadra cautella*, *Lasioderma serricorne*, *Ephestia elutella*, *Plodia interpunctella*, *Dermestes maculatus* De Geer, *Trogoderma granarium*, *Attagenus unicolor japonicus* Reitter, *Anthrenus verbasci*, *Liposcelis bostrychophila* Badonnel, and the like.

EXAMPLES

[0053]

The present invention will be described below more specifically by means of Examples. However, the present invention is obviously not restricted only to the Examples.

<Example 1>

[0054]

A treatment chamber as shown in FIG. 4 was adopted as a treatment chamber of a water vapor plasma treatment apparatus as shown in FIG. 1; the output power of a high-frequency wave, the frequency of the current, the temperature of water vapor plasma were set at 30 kW, 9 to 35 kHz, and 400°C, respectively;

and peanuts were loaded from the input port and irradiated for 15 seconds with water vapor plasma emitting from the opening for water vapor plasma application.

Next, the peanuts irradiated with water vapor plasma were transferred into a container made of polyethylene, the peanuts were then dusted with a calcined powder of a natural calcium-rich material obtained by calcination of petrified coral at 1,200°C at a ratio of 0.1% by weight; and the container was shaken several times such that the powder was applied to the entire body of each peanut.

The container containing the peanuts which had undergone the plasma irradiation and the powder application was sealed and stored at room temperature for 4 months.

<Comparative Example 1>

[0055]

Peanuts were placed in a container made of polyethylene without performing the plasma irradiation and the application of the calcined powder of the natural calcium-rich material both shown in Example 1 and the container was sealed and stored at room temperature for 4 months.

[0056]

Upon observing the containers after 4 months of storage, any growth of mold was not observed at all in the peanuts which had undergone the plasma irradiation and the application of the calcined powder of the natural calcium-rich material.

On the other hand, the situation of the peanuts without

the treatments was bad and mold grew. This mold species is likely to be *Aspergillus flavus*, which produces aflatoxin. These results are shown in FIG. 6.

The peanuts were stored further and also observed when 595 days passed after the treatments. Surprisingly, the peanuts which had undergone the plasma irradiation and the application of the calcined powder of the natural calcium-rich material of the present invention did not show growth of mold even after such a long storage period. These results are shown in FIG. 7.

<Examples 2-1 and 2-2 and Comparative Example 2>

[0057]

Red wheat grains were subjected to the plasma irradiation and the application of the calcined powder of the natural calcium-rich material as shown in Example 1. A container containing the treated red wheat grains was sealed and stored at room temperature for 4 months (Example 2-1).

Furthermore, red wheat grains were treated as in Example 2-1 except that the temperature of the water vapor plasma was adjusted to 500°C, and a container containing the treated red wheat grains was sealed and stored at room temperature for 4 months (Example 2-2).

Furthermore, red wheat grains were placed in a container made of polyethylene without performing the plasma irradiation and the application of the calcined powder of the natural calcium-rich material and the container was sealed and stored

at room temperature for 4 months (Comparative Example 2).

[0058]

Upon observing the containers after 4 months of storage, any growth of mold was not observed at all in the red wheat grains which had undergone the plasma irradiation and the application of the calcined powder of the natural calcium-rich material (Example 2-1 and Example 2-2).

On the other hand, the situation of the red wheat grains without the treatments was bad and mold grew. This mold species is likely to be a mold species which can produce a mycotoxin (Comparative Example 2).

<Example 3>

[0059]

Yellow lentils were subjected to the plasma irradiation and the application of the calcined powder of the natural calcium-rich material as shown in Example 1 except that the amount of the calcined powder of the natural calcium-rich material applied was adjusted to an amount equal to 0.2% by weight of the yellow lentils. A container containing the treated yellow lentils was sealed and stored at room temperature for 4 months.

[0060]

Upon observing the container after 4 months of storage, any growth of mold was not observed at all in the yellow lentils which had undergone the plasma irradiation and the application of the calcined powder of the natural calcium-rich material

(Example 3).

INDUSTRIAL APPLICABILITY

[0061]

The present invention enables long-term food preservation without mold growth. The present invention can reduce damage by fungal toxins, such as mycotoxin, associated with mold growth. Furthermore, because growth of mold itself can be suppressed, the storage life of food is significantly increased and therefore the industrial applicability of the present invention is quite high.

EXPLANATION OF SYMBOLS

[0062]

1. water vapor plasma treatment apparatus
10. water vapor generating apparatus
11. object to be heated
11a. disk member to be heated
12. coil
13. heat insulator
20. treatment chamber
21. main body of the treatment chamber
22. input port
23. input adjusting portion
24. opening for water vapor plasma application
25. installation table
30. inverter

31. conductive wire

40. water vapor boiler

50. coolant tank

51. inlet hose

52. outlet hose

60. conduit

61. on-off valve

62. check valve

71. water vapor inlet portion

72. water vapor plasma discharging portion

73. jet nozzle

74. water vapor plasma leading tube

111a. through-hole

112a. groove

113a. space

211. treatment chamber

211a. main body of the treatment chamber

211b. top cover

212. rotating object

212a. net portion

212b. screw impeller

212c. stirring flat plate

212d. fixing portion

212e. input opening

213. water vapor supplying portion

214. motor

215. gear portion

216. input portion

217. bolt

218. gear wheel

219. guiding plate

222b. screw impeller

222g. rotation shaft

CLAIMS

1. A food sterilization and preservation method comprising a water vapor plasma irradiation step of irradiating a food with water vapor plasma and a step of applying a calcined powder of a natural calcium-rich material to the food which has undergone the water vapor plasma irradiation step.

2. The food sterilization and preservation method according to claim 1, wherein said water vapor plasma is at not less than 250°C and not more than 850°C.

3. The food sterilization and preservation method according to claim 1 or 2, wherein the irradiation time of said water vapor plasma is not less than 3 seconds and not more than 120 seconds.

4. The food sterilization and preservation method according to any one of claims 1 to 3, wherein said plasma is generated by a water vapor plasma generating apparatus comprising: a conductive object to be heated which discharges inflow water vapor as water vapor plasma; and a coil which wraps around said object to be heated and is supplied with a high-frequency currentto heat said object to be heated by electromagnetic induction, wherein said object to be heated comprises a plurality of members to be heated provided continuously and integrally from an inlet side of the water vapor toward an outlet side of the water vapor plasma, wherein through-holes which gradually decrease in number as disposed positions thereof shift from the inlet side of the water vapor toward the outlet side of the water vapor plasma, and concave portions which

constitute passing regions for the water vapor together with said through-holes on at least one of surfaces opposed to each other are formed in said plurality of members to be heated, and wherein said coil comprises a hollow tube at a center of its wiring body and said hollow tube is a flow path where a coolant flows.

5. The food sterilization and preservation method according to any one of claims 1 to 4, wherein said calcined powder of the natural calcium-rich material is applied at a ratio of 0.001 to 2% by weight.

6. The food sterilization and preservation method according to any one of claims 1 to 5, wherein said calcined powder of the natural calcium-rich material is obtained by calcination at a calcination temperature of 1,000°C or more.

7. A food production method comprising processing a food by the food sterilization and preservation method according to any one of claims 1 to 6.

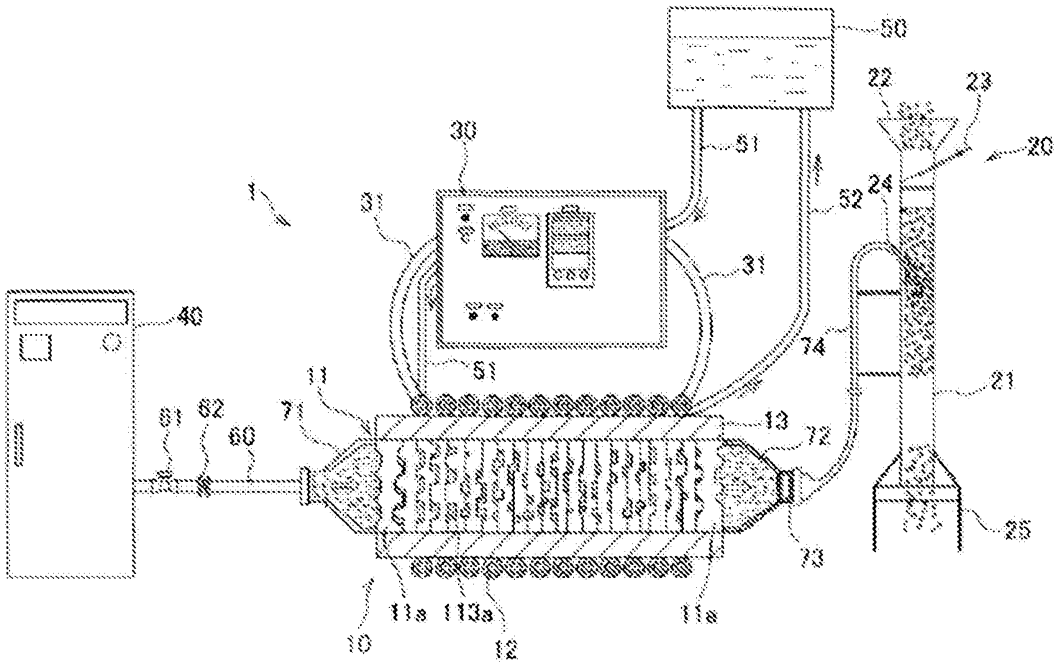

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Fig. 1

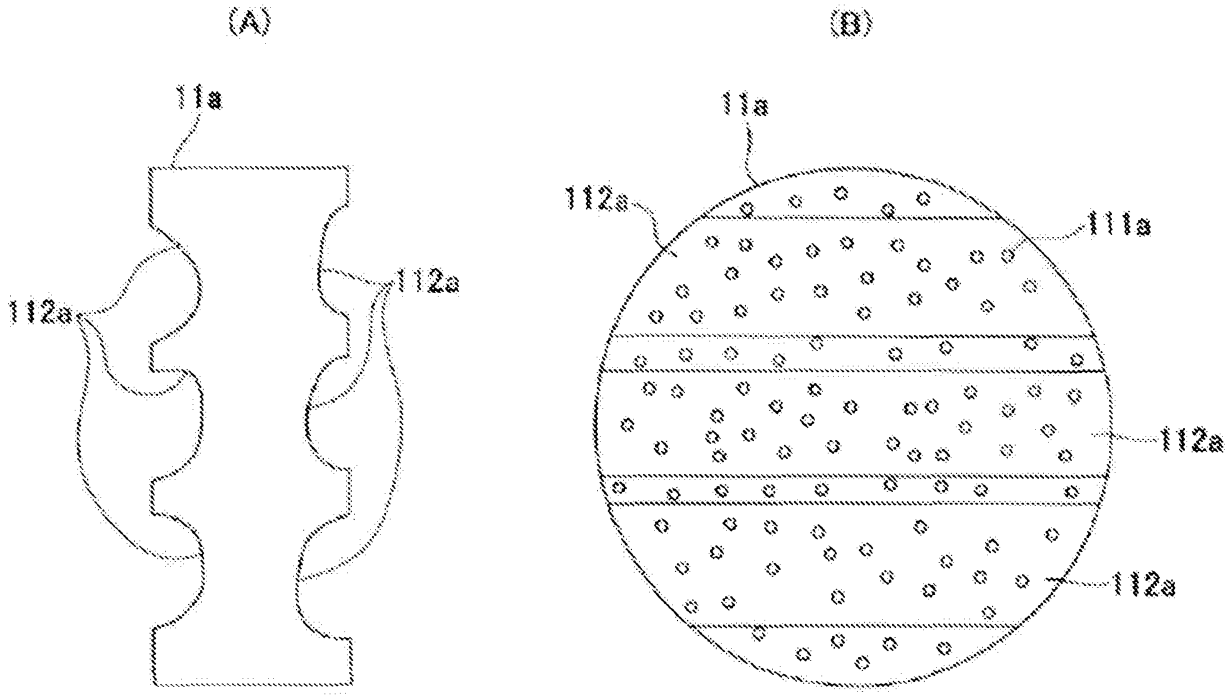


Fig. 2

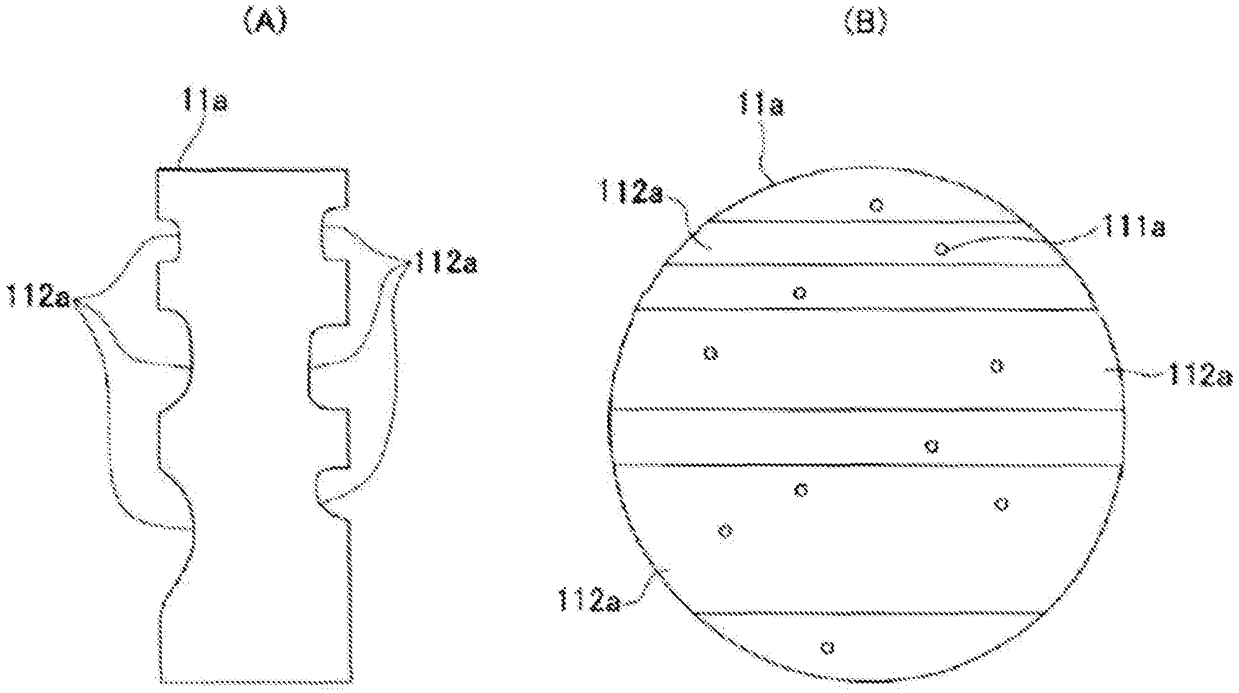


Fig. 3

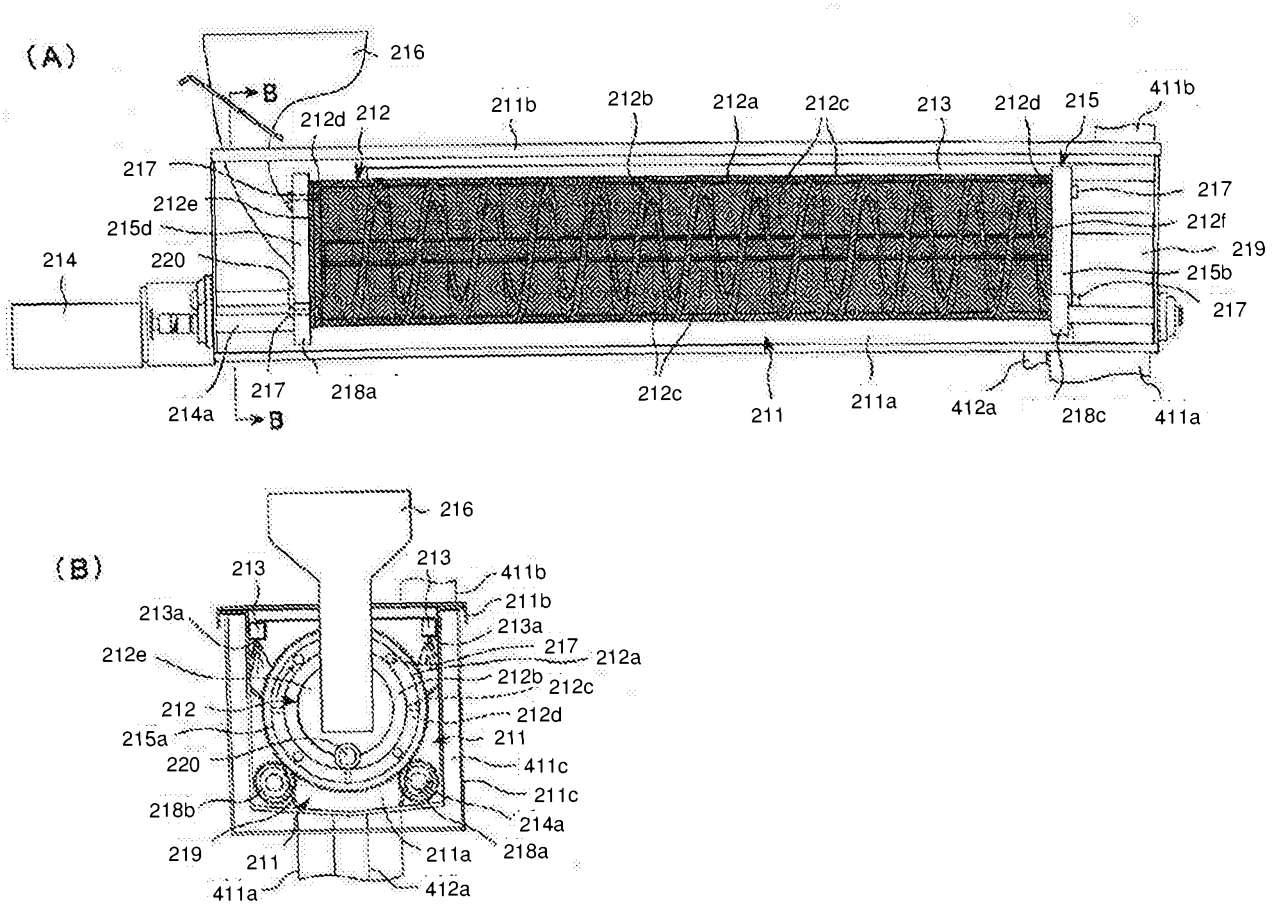

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Fig. 4

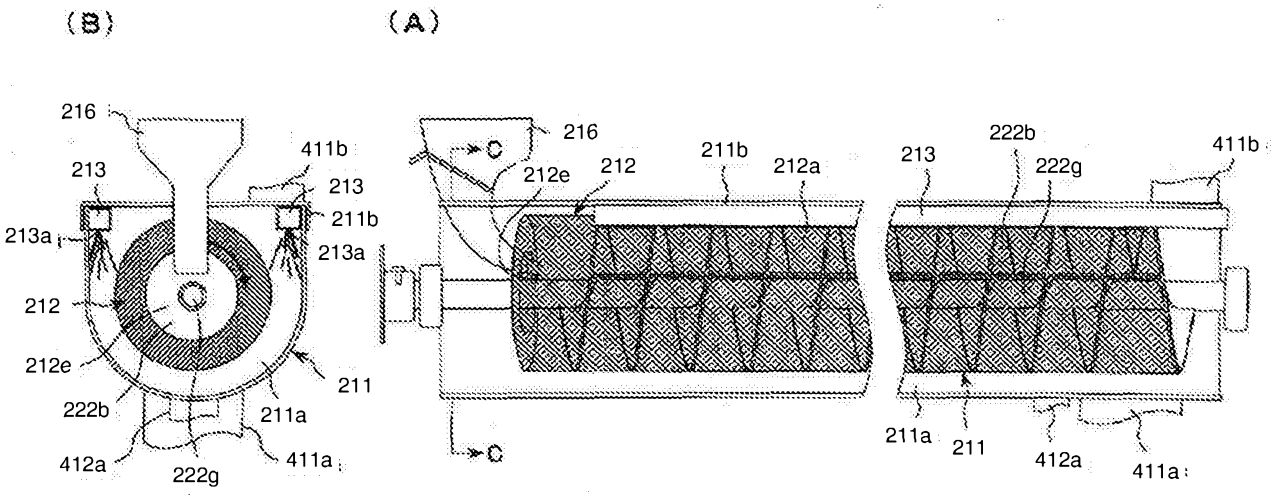

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Fig. 5

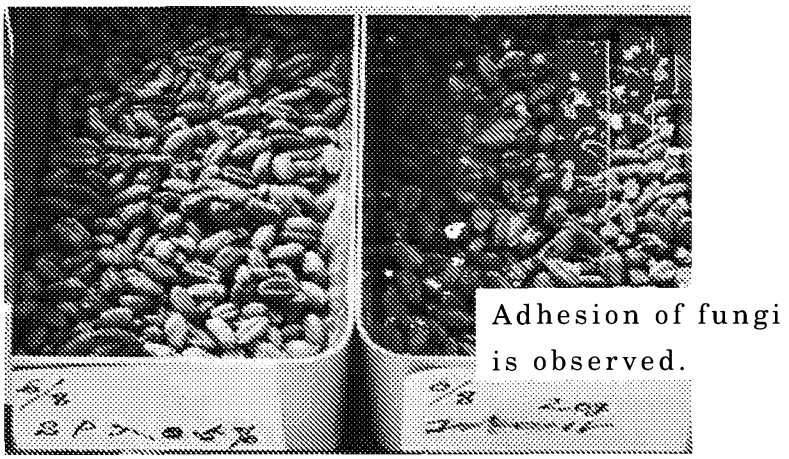


Fig. 6

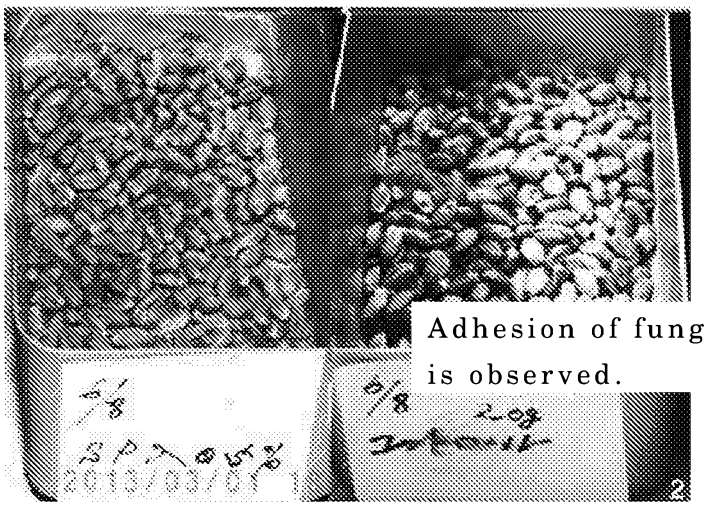


Fig. 7