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(54) Title: VEGETATIVE STERILIZATION METHOD

(57) Abstract

A method of sterilizing vegetative material by extrusion. The method includes providing a vegetative material and an extruder including a housing and an extended barrel. The vegetative material is sterilized by being extruded through the housing and into the extended barrel at temperatures, pressures, and residence time sufficient to kill microorganisms existing in the vegetative material. In a specific implementation, the housing has an inlet, an outlet, and first and second screws configured and arranged such that the second screw is longer than the first screw. The screws are positioned within the housing with respect to one another such that the second screw extends within the housing past the first screw proximate the outlet. An oxidizing agent is added to the vegetative material, followed by sterilization of the vegetative mateial by extruding it through the housing and into the extended barrel such that the vegetative material reaches a temperature greater than 200 °F, and a pressure of between 100 and 2,500 pounds per square inch.

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VEGETATIVE STERILIZATION METHOD

Background of the Invention

Vegetative material is one of the most important components of the human diet. In addition to various fruits, vegetables, and grains; vegetative material includes such ingredients as spices that are used to enrich the flavor, aroma, appearance, and nutrition of many foods. Such spices are widely sold in grocery stores and specialty shops for consumers. In addition, spices are often incorporated into various processed, prepackaged food products. These prepackaged food products range from frozen pizzas, pastas, sauces and sandwiches to delicatessen salads and soups. Prepackaged food products are prepared in advance for consumers who desire time savings and ease in preparing meals. These products often only require re-heating or slight cooking in order to be consumed. The ability to purchase such products in advance, and then keep them in a refrigerator or freezer for extended periods of time, has made them an important portion of many people's diets.

Prepackaged food products often sit for days, weeks, or even months between the time they are produced and the time they are consumed. Even when kept at relatively low temperatures above or below freezing, these products can be detrimentally harmed by the presence of microorganisms. Bacteria and mold, for example, can significantly alter the taste and fresh flavor. In the worst situations, the microorganisms can be a health threat if their concentrations are too high. Under these conditions, even low numbers of bacteria, mold or other microorganisms can spoil the food and cause outbreaks of sicknesses. For this reason, any manner to preserve the integrity of the food and its flavor in the spices or flavorings is desirable.

Extensive cooking of vegetative material at high temperatures and long cooking times can accomplish sterilization. While such methods will sterilize spices, they have significant draw backs, because the spices are often significantly degraded during the sterilization. The complex nature of many spice components makes them vulnerable to degradation when exposed to excessive heat. In addition, problems can arise due to the relative volatility of many spice components. These volatile components are lost through evaporation when sterilized according to traditional cooking-type sterilization methods. This loss can result in a dramatic decline of flavor and richness from the spices, and thus result in a significant reduction, if not elimination, of the benefits and pleasure associated with using spices.

Thus, a need exists for an improved method of sterilizing vegetative material, including spices, to enhance their safety, while preventing the degradation and loss of the flavors. This method should be efficient and cost-effective.

Summary of the Invention

The present invention is directed to a method of sterilizing vegetative material, including spices, by extrusion cooking. The invention is also directed to a sterilized vegetative product produced using the method of the invention. The method includes providing a vegetative material and an extruder including a housing and an extended barrel. The vegetative material is sterilized by being extruded through the housing and into the extended barrel at a temperature, pressure, and residence time sufficient to kill microorganisms existing in the vegetative material.

In a specific implementation, the housing has an inlet, an outlet, and first and second screws configured and arranged such that the second screw is longer than the first screw. Various types of extruder screws are used in order to sterilize vegetative material according to the invention. The screws are positioned within the housing with respect to one another such that the second screw extends past the first screw proximate the outlet of the housing. In other implementations, only one extruder screw is used. An oxidizing agent is added to the vegetative material in specific implementations, followed by sterilization of the vegetative material by extruding it through the housing and into the extended barrel.

The vegetative material is, for example, onion powder, black pepper, garlic powder, granulated garlic, cocoa powder, celery powder, paprika, oregano, ginger, cinnamon, nutmeg, chili powder, sesame seeds, cardamom, coriander, parsley, mace, curry, sage, thyme, basil, dill, dill seeds, mint, chives, bay leaves, cloves, tarragon leaves, fennel, cayenne pepper, marjoram, or red pepper.

In a specific embodiment, the vegetative material has a residence time in the housing of between 30 seconds and 5 minutes; and a residence time in the barrel of between 5 minutes and 30 minutes. The vegetative material reaches a temperature of between 100°F and 350°F and a pressure greater than 100 pounds per square inch. The vegetative material exits the barrel at a temperature greater than 212°F.

In certain implementations, an oxidizing agent is added to the vegetative material in order to assist in the elimination of microorganisms. An oxidizing agent is a material that brings about oxidation and in the process is itself reduced. The oxidizing agent is, for example, ozone, hydroxide, chloride, nitrate, sulfur dioxide, and combinations of these oxidizing agents. Other examples include acetone peroxide, benzoyl peroxide, and calcium peroxide.

The above summary of the present invention is not intended to describe each discussed embodiment of the present invention. This is the purpose of the figures and the detailed description which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

Other aspects and advantages of the invention will become apparent upon reading the following detailed description and references to the FIGURES, in which:

FIG. 1 is a side elevational view of a sterilizer constructed in accordance with the present invention, showing a sterilizer housing and an extended barrel.

FIG. 2 is a partial cut-away view of the sterilizer depicted in FIG. 1, showing exposed extruder screws.

FIG. 3A is a cross-sectional view of the sterilizer depicted in FIG. 1, showing a cross-section taken along lines A-A'.

FIG. 3B is a cross-sectional view of the sterilizer depicted in FIG. 1, showing a cross-section taken along lines B-B'.

FIG. 3C is a cross-sectional view of the sterilizer depicted in FIG. 1, showing a cross-section taken along lines C-C'.

FIG. 3D is a cross-sectional view of the sterilizer depicted in FIG. 1, showing a cross-section taken along lines D-D'.

FIG. 4 is a partial cut-away view of a housing showing a single-screw extruder.

While the invention is susceptible to various modifications and alternative forms, specifics thereof have been shown by way of example and figures, and will be described in detail. It should be understood, however, that the intention is not to limit the invention to particular embodiments described. On the contrary, the intention is to cover modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

The present invention is directed to a method of sterilizing vegetative material, including spices, by extrusion heating. The invention is also directed to a sterilized vegetative product produced using the method of the invention. The method includes providing a vegetative material and an extruder including a housing and an extended barrel. The vegetative material is sterilized by being extruded through the housing and into the extended barrel at a temperature, pressure, and residence time sufficient to kill microorganisms existing in the vegetative material.

In reference now to FIGS. 1, 2, and 3, FIG. 1 shows a side elevational view of a sterilization apparatus 10 having an extruder housing 12 and an extended barrel 14. The extruder housing 12 includes a first section 16, a second section 18, and a third section 20. An inlet 13 and outlet 15 are positioned proximate opposite ends of the housing 12. The extended barrel 14 has a first section 22, a second section 24, and a third section 26. While the sterilization apparatus is shown having a three-section extruder housing 12 and a three section extended barrel 14, the housing 12 and the extended barrel 14 are made of more or fewer sections in different implementations of the invention. In addition, in specific implementations, the sterilization apparatus 10 does not include an extended barrel 14, but only a housing 12 configured to sufficiently raise the temperature and pressure of the spices to kill microorganisms.

The housing 12 and the extended barrel 14 combine to define a continuous hollow channel through which spices (or other vegetative material) are forced during sterilization. The spices enter the extruder by way of a metering apparatus 28 and are driven by an extruder screw or screws (shown in FIG. 2) through the housing 12 and into the extended barrel 14. While driven along the housing 12 and extended barrel 14, the spices are heated and pressurized, resulting in the death or inactivation of microorganisms contained in the spices.

In addition to the specific elements of the housing 12 and barrel 14 identified above, the sterilization apparatus 10 includes a drive means 30 for powering the screws that drive the spices through the housing 12. Also, a distributor 32 is positioned intermediate the third section 20 of the housing 12 and the first section 22 of the extended barrel 14. The distributor 32 aids in the proper distribution of the spices within the barrel 14 by distributing the spices to the periphery of the barrel 14, thereby allowing improved plug flow of material through the barrel. A die 34 is positioned proximate the third (or final) section 26 of the extended barrel 14. Die 34 distributes the spices before they enter a cutter 36. In addition, a container 38 containing an oxidizing agent or sterilizing agent 21 is included in specific implementations of the invention. Once the product reaches the end of the barrel, it enters the die area and then the cutter 36.

Now, in reference to FIG. 2, the interior of the housing 12 is depicted, showing first and second extrusion screws 38, 40 respectively. The first extrusion screw 38 is shown significantly shorter than the second extrusion screw 40. Screws 38, 40 include shafts 42, 44 and blades 46, 48 respectively. The screws 38, 40 are positioned within the housing such that they overlap each other proximate the inlet 13, but only the second screw 40 extends to the outlet 15. Second screw 40 includes a first portion 40a and a second portion 40b. First portion 40a overlaps

with the first screw 38, while the second portion 40b does not overlap the first screw 38. In operation, spices are driven by rotation of the screws from overlapping portions of the first and second screws 38, 40 to the non-overlapping portion of the second screw 40.

The spices or other vegetative material preferably enters inlet 13 to housing 12 with an accurate and continuous feeding mechanism. The spices are, for example, in a dry floury format or in a liquid pumping format. In specific implementations, once the product is in the extruder housing 12, the oxidizing agent is added as either a liquid, a gas, or a mixture of a liquid and gas that is pumped into the extruder housing 12 to be mixed with the spices. The screws 38, 40 not only mix the spices with the oxidizing agent, but also heat them by conductive and convective application of thermal energy. As the spices move through the housing 12, they are fully heated, mixed, and pressurized. The spices then move into the extended barrel 14. The sections 22, 24, 26 of the extended barrel 14 hold the extrudate with a long residence time so that the heat and any oxidizing agents or sterilizing agents infiltrate and kill microorganisms.

In reference now to FIGS 3A, 3B, 3C, and 3D, the ends of various portions of the housing and barrel are shown. FIG. 3A, taken along line A-A' of FIG. 1, shows the interior of the housing 12, and in particular an upper lobe 12a and lower lobe 12b. The upper lobe 12a contains the first screw 38, while the lower lobe 12b contains the first portion 40a of the second screw 40 (shown in FIG. 2). In addition, FIGS. 3A, 3B, and 3D show mounting holes 50 into which are fostered holds to hold the sections of the housing and barrel together.

FIG. 3B, taken along line B-B' of FIG. 1, shows the interior of the housing 12 with a single lobe 12c configured to contain the second portion 40b of the second screw 40. FIG. 3C, taken along line C-C', shows a cross-section of the distributor 32, with a multitude of openings 52. The openings 52 direct the spices to the periphery of the barrel. FIG. 3D, taken along line D-D', shows the interior of the extended barrel 14.

The extended barrel is wrapped with heating or cooling elements in order to maintain or alter the temperature of the interior of the barrel. The heating elements are, for example, steam jackets or electric heating elements wrapped around the exterior of the barrels. The heating elements cover all of the barrels or only portions of the barrels, and are controlled independently in specific implementations so that the temperature may be varied along the length of the extended barrel.

While within the sterilization apparatus 10, the spices reach a temperature in excess of 100° F; preferably between 100° F and 350° F, and more

preferably between 200° F and 300° F. The spices are raised to a pressure of between 100 and 2,500 pounds per square inch (psi), or between 500 and 1,000 psi.

In a specific embodiment, the vegetative material has a residence time in the housing of between 30 seconds and 5 minutes; and a residence time in the barrel of between 5 minutes and 30 minutes. The vegetative material reaches a temperature of between 100°F and 350°F, a pressure greater than 100 pounds per square inch, and the vegetative material exits the barrel at a temperature greater than 212°F.

The vegetative material is, for example, onion powder, black pepper, garlic powder, granulated garlic, cocoa, celery powder, paprika, oregano, ginger, cinnamon, nutmeg, chili powder, sesame seeds, cardamom, coriander, parsley, mace, curry, sage, thyme, basil, dill, dill seeds, mint, chives, bay leaves, cloves, tarragon leaves, fennel, cayenne pepper, marjoram, or red pepper.

As discussed above, various types of extruder screws are used in order to sterilize vegetative material according to the invention. One type of extruder has a first screw and a second screw aligned parallel to each other. The first and second screws are configured and arranged such that the second screw is longer than the first screw, and the screws are positioned with respect to one another such that the second screw extends past the first screw proximate the outlet. In reference now to FIG. 4, an implementation is shown in which the housing 112 contains a single screw 138. In still other implementations, the housing contains two screws that are equal in length.

Thus, the invention debacterializes or sterilizes various spices and ingredients in the food industry. It utilizes the pumping and mixing and conductive heat exchange characteristics of the twin screw extruder and the slow low shear pumping of the single screw extruder followed by the holding barrel to hold the heated or steamed vegetative material within confines of a chamber at temperatures of 100-350°F and pressures of 100-2,500 psi. Other ingredients, such as oxidizing agents and debacterializing or sterilizing agents, are added at a very low quantity to be infused into the material. This method results in a final product that is debacterialized, and even the destruction of spores within the vegetative material without significant change in the product matrix or physical character.

The processing technique includes a first part being the use of a twin screw extruder in which the raw powder is mixed with some oxidizing agent such as peroxide carried in moisture or other ingredients or in a form of ozone gas mixed directly into the extruder or mixed with water before entering the extruder. At this point, the raw material is totally mixed with the oxidizing agent no matter how small a quantity is being used.

By the midpoint of the extrusion system, the product is not only well mixed with the oxidizing agent, but it is also super heated to a point where the water is transformed into vapor stage and has infiltrated into the product. The product containing the oxidizing or debacterializing agent is then further pressurized in the extended barrel with minimum shear and residence time of up to 20 minutes or may enter the die area directly at which time the product is either shaped and forced to enter a die hole or is readily expelled with minimum pressure.

The product in the extended barrel is pressurized by three means. First, by the resistance of the product to flow in a plug flow pattern and the resistance to slippage that the product is formed with the wall of the barrel. Second, by resistance to flow at the distribution where the product is distributed through peripheral of the center of the barrel. Third, by the die area where the holes and the distribution center creates resistance to the flow of the product in a forward direction and thus generate backup pressure that further creates high pressures and results in puffing of the product as it exits the die.

The sudden release of pressure at the die, as well as the oxidizing agent and heat, result in almost all living organisms being either lysed, killed or deactivated. The method also leaves most spores inactive or destroyed. To specifically treat the spores, the addition of certain commercially available proteins overcomes the viability of these spores by attachment of such proteins to the surface of the spores.

Tests were conducted to determine the efficacy of the method on sterilizing various raw vegetative materials. Table 1 summarizes the results of the tests.

Table 1

Raw Material	Total Plate Count Before Sterilization (count/gram)	Total Plate Counter After Sterilization (count/gram)
onion powder	1,000,000	0
pepper	500,000	0
onion powder	6,000,000	4,000
onion powder	12,000,000	6,000
tumeric	400,000	0
garlic powder	500,000	0
cocoa powder	600,000	8,000

No oxidizing agents were used in the tests to obtain the indicated results.

It was noted during testing that in most cases a need exists for at least a few minutes of retention time in order to achieve a good kill in this process. The results indicated that, during the processing of onion powder starting with 12,000,000 counts, the method allowed reduction of the counts to 6,000/gm. Such a large reduction in the bacterial count was coupled with the clarity or whiteness of the color and no off flavor.

The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

I Claim:

1. A method of sterilizing vegetative material, the method comprising:
   a) providing a vegetative material;
   b) providing an extruder including:
      i) a housing having an inlet, an outlet, and at least one extruder screw, and
      ii) an extended barrel proximate the outlet of the housing; and
   c) sterilizing the vegetative material by extruding the vegetative material through the housing and into the extended barrel.

2. The method of sterilizing vegetative material according to claim 1, wherein the vegetative material is selected from the group consisting of onion powder, black pepper, garlic powder, granulated garlic, cocoa powder, celery powder, paprika, oregano, ginger, cinnamon, nutmeg, chili powder, sesame seeds, cardamom, coriander, parsley, mace, curry, sage, thyme, basil, dill, dill seeds, mint, chives, bay leaves, cloves, tarragon leaves, fennel, cayenne pepper, marjoram, red pepper and combinations thereof.

3. The method according to claim 1, wherein the housing contains two extruder screws comprising a first screw and a second screw aligned parallel to each other.

4. The method according to claim 3, wherein the first and second screws are configured and arranged such that the second screw is longer than the first screw, and the screws are positioned with respect to one another such that the second screw extends past the first screw proximate the outlet.

5. The method according to claim 1, wherein the vegetative material has a residence time in the housing of between 30 seconds and 5 minutes.

6. The method according to claim 1, wherein the vegetative material has a residence time in the barrel of between 5 minutes and 30 minutes.

7. The method according to claim 1, wherein the vegetative material reaches a temperature of between 100°F and 350°F.

8. The method according to claim 1, wherein the vegetative material reaches a temperature greater than 200°F.

9. The method according to claim 1, wherein the vegetative material reaches a pressure greater than 100 pounds per square inch.

10. The method according to claim 1, wherein the vegetative material reaches a pressure between 100 and 2,500 pounds per square inch.

11. The method according to claim 1, wherein the vegetative material reaches a pressure between 500 and 1,000 pounds per square inch.

12. The method according to claim 1, wherein the vegetative material reaches a pressure between 100 and 2,500 pounds per square inch; a temperature between 100°F and 350°F; and has a retention time in the extended barrel of between 3 minutes and 30 minutes.

13. The method according to claim 1, further comprising the vegetative material exiting the barrel at a temperature greater than 212°F.

14. The method according to claim 1, further comprising the step of adding an oxidizing agent to the vegetative material.

15. The method according to claim 14, wherein the oxidizing agent comprises ozone.

16. The method according to claim 14, wherein the oxidizing agent is selected from the group consisting of alcohol, acetone, aldehydes, hydroxide, chloride, nitrate, sulfur dioxide, and combinations thereof.

17. A method of sterilizing vegetative material, the method comprising:

a) providing a vegetative material;

b) providing an extruder, the extruder including:

i) a housing having an inlet, an outlet, and first and second screws configured and arranged such that the second screw is longer than the first screw, and the screws are positioned within the housing with respect to one another such that the second screw extends within the housing past the first screw proximate the outlet to the housing;

ii) an extended barrel proximate the outlet of the housing and in communication with the housing;

c) adding an oxidizing agent to the vegetative matter; and

d) sterilizing the vegetative material by extruding the vegetative material through the housing and into the extended barrel such that the vegetative material reaches a temperature greater than 200°F, and a pressure of between 100 and 2,500 pounds per square inch.

18. The method according to claim 17, wherein the vegetative material is selected from the group consisting of onion powder, black pepper, garlic powder, granulated garlic, cocoa powder, celery powder, paprika, oregano, ginger, cinnamon, nutmeg, chili powder, sesame seeds, cardamon, coriander, parsley, mace, curry, sage, thyme, basil, dill, dill seeds, mint, chives, bay leaves, cloves, tarragon leaves, fennel, cayenne pepper, marjoram, red pepper and combinations thereof.

19. The method according to claim 17, wherein the oxidizing agent is selected from the group consisting of ozone, hydroxide, chloride, nitrate, sulfur dioxide, and combinations thereof.

20. The method according to claim 17, wherein the vegetative material has a retention time in the extended barrel of between 5 minutes and 30 minutes.

21. A sterilized vegetative material manufactured according to the method of claim 1.

22. A sterilized vegetative material manufactured according to the method of claim 17.

FIG. 1

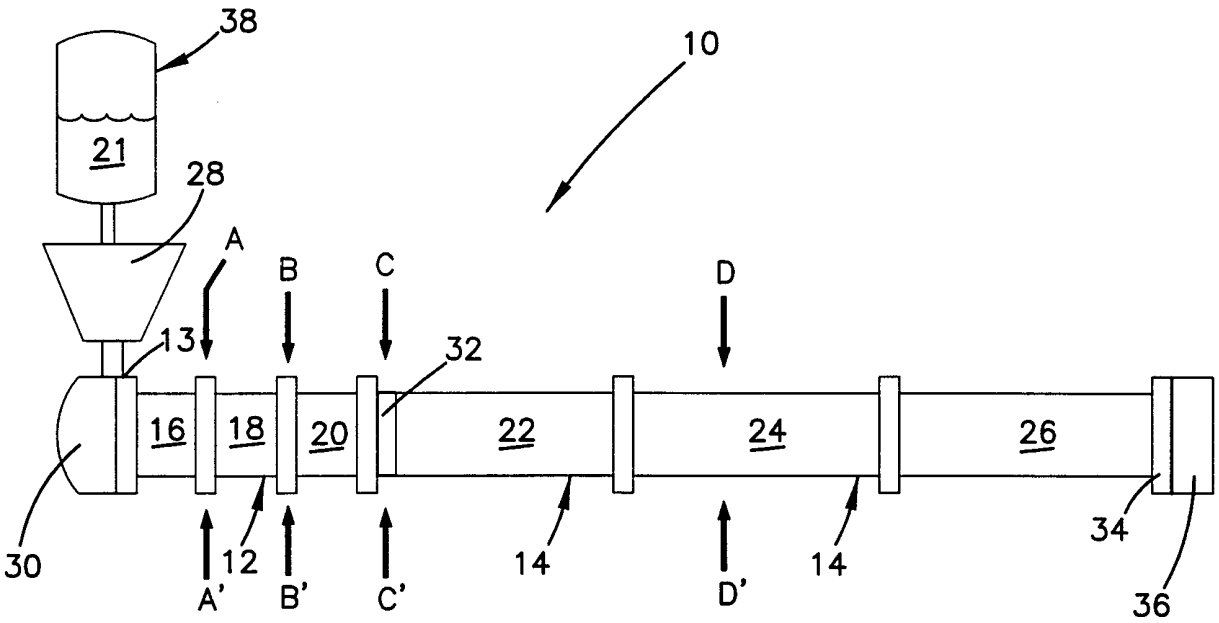
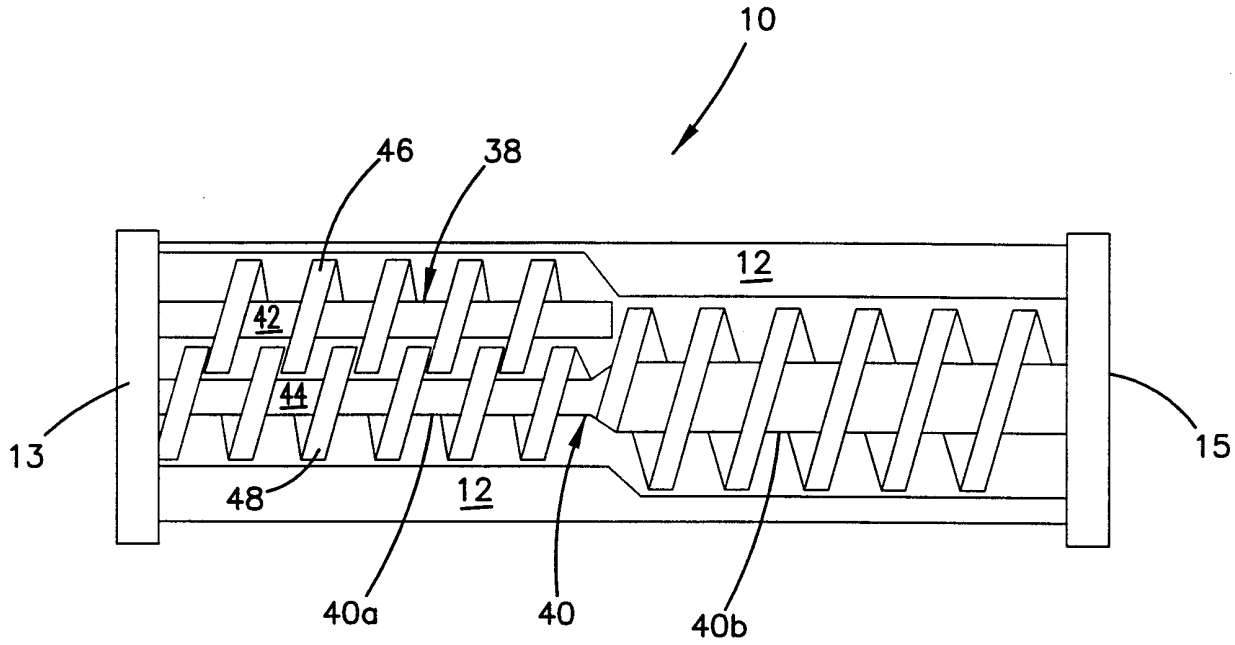


FIG. 2



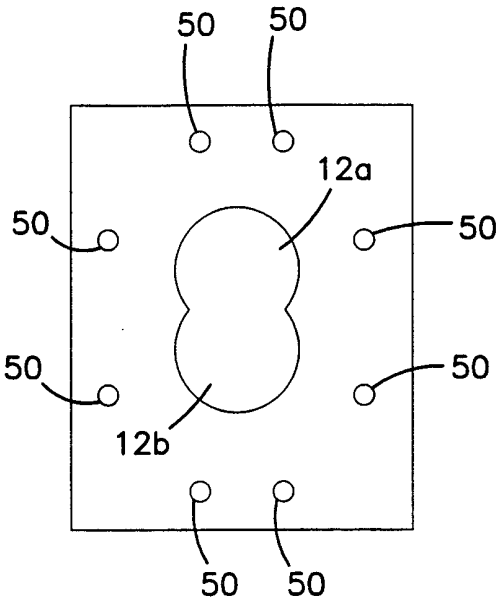


FIG. 3A

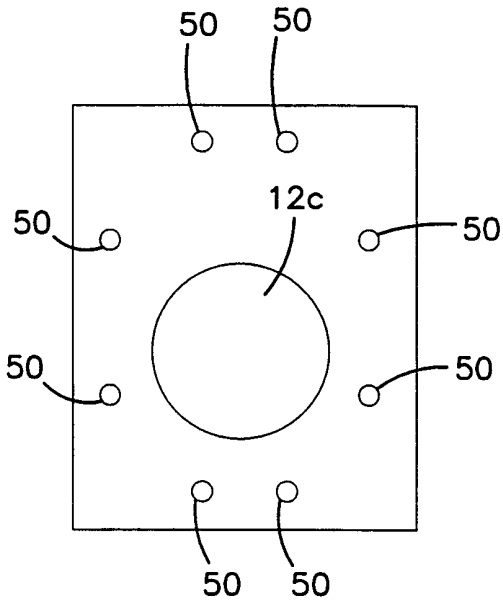


FIG. 3B

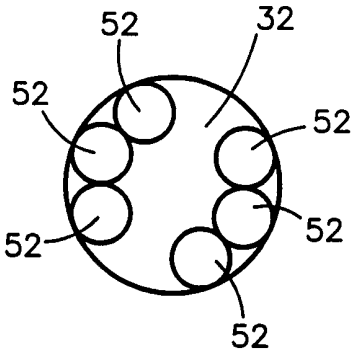


FIG. 3C

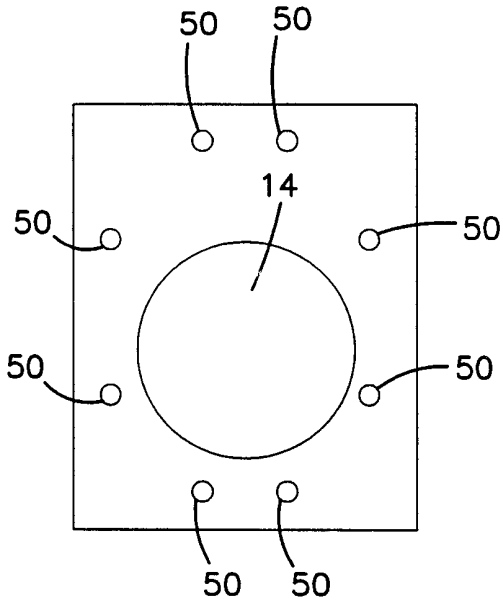
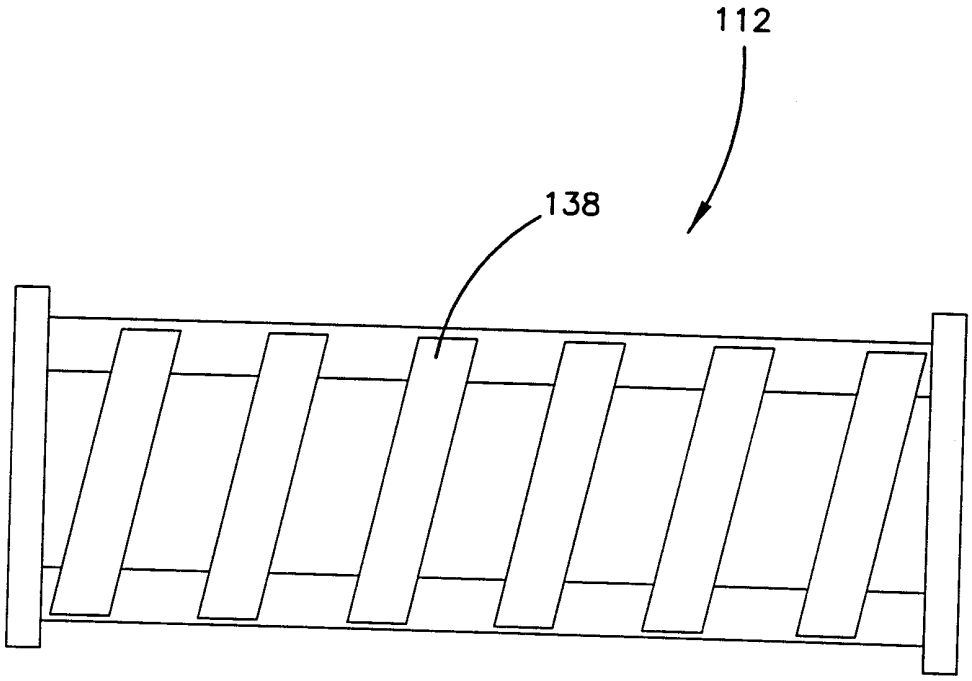


FIG. 3D

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/04539

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A23L 3/015
US CL :422/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

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

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

APS
search terms: spice(s), extruders, extrusion, sterilization

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,210,678 A (BAYUSIK et al) 01 July 1980, whole document, especially claim 1.	1-, 7-11, 13, 21 --------- 3-6, 12, 14-16
Y	US 4,658,708 A (RASTOIN) 21 April 1987, whole document, especially figures.	3 and 4
Y	US 5,296,247 A (HUANG et al) 22 March 1994, whole document, especially figures.	3 and 4
Y	US 5,523,053 A (DUDEK) 04 June 1996, whole document, especially column 7.	5-6 and 12
Y	US 3,897,210 A (GRUBER et al) 29 July 1975, whole document, especially column 2.	14-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 12 APRIL 1999	Date of mailing of the international search report 20 MAY 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer FARIBORZ MOAZZAM BRIAN A. HARDEN PARALEGAL SPECIALIST GROUP 1700 Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)*

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

422/32, 1, 26-28, 33, 186, 186.02, 186.07, 188, 196, 197, 224-226, 292, 295, 297, 300, 307 -309; 426/235, 276, 312, 320, 443, 448, 449, 516, 519