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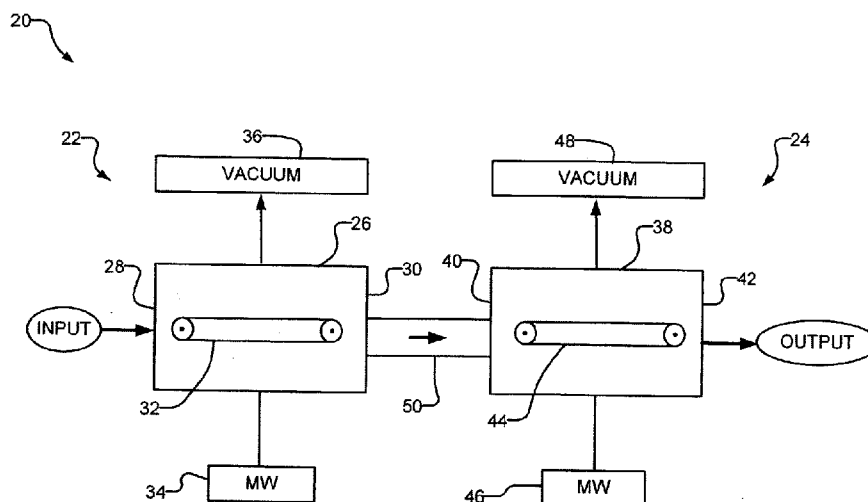


FIG. 1

(57) **Abstract:** A method and apparatus for pasteurizing and drying marijuana plant materials using a microwave-vacuum chamber. The pasteurizing and drying are carried out with no use of ionizing radiation and with rapid drying. Pasteurization is done at a temperature and for a time period that are sufficient to reduce microorganisms to an acceptably low level, while not significantly reducing the psychoactive compounds in the material. In the process, the pressure inside a vacuum chamber is reduced to a first pressure less than atmospheric. The material is maintained in the vacuum chamber at the first pressure at a pasteurizing temperature while irradiating the material with microwave radiation. The pressure is then reduced to a second pressure lower than the first pressure and the material is maintained in the vacuum chamber at the second pressure for a time period at a dehydrating temperature lower than the pasteurizing temperature while irradiating the material with microwave radiation. The pasteurizing and dehydrating steps can be done in the reverse order.



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METHOD AND APPARATUS FOR PASTEURIZING AND DEHYDRATING MARIJUANA

Field of the Invention

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The invention pertains to the methods and apparatus for the preparation of marijuana (cannabis) for human use.

Background of the Invention

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Both pasteurization and dehydration are necessary steps in preparing marijuana for human use, whether medical or, where legal, recreational use. Dehydration must retain sufficient terpenes and the psychoactive chemical ingredients, including THC (tetrahydrocannabinol) and other cannabinoids. Pasteurization must destroy potentially

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pathogenic microorganisms that may be present on the marijuana plant material. Because marijuana is often consumed by smoking, pathogenic microorganisms may be carried into the lungs and cause pneumonia or other disease conditions. Pasteurization is especially critical in medical applications because the patients who are prescribed marijuana are often immunocompromised and hence especially vulnerable to infections.

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The current practice in the industry is to dry the marijuana plant material by air drying at room temperature, which typically requires five to six days. Decontamination is done by means of ionizing radiation, which is the only pasteurization technique currently available to the industry. It is carried out using highly specialized equipment, typically at a facility separate from the drying facility, making it an expensive and troublesome operation for

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the marijuana industry. It is also a controversial process for some patients and consumers because ionizing radiation is considered an undesirable process by some consumers, especially in some European countries such as Germany. Moreover, the cost of production is increased by the security required at both facilities and during

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Summary of the Invention

The invention provides a method of pasteurizing and drying marijuana plant materials in which the pasteurizing and drying are carried out in a single facility, even in a single

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- apparatus, with no use of ionizing radiation and with rapid drying, producing a high quality product. The inventors have determined that the pasteurization and dehydration of marijuana plant material can be done using microwave radiation at reduced pressure in a vacuum chamber, in a manner that effectively pasteurizes the plant material, and
- 5 dries it, while not significantly reducing the active components in the material. The pasteurization is done at a temperature and for a time period that are sufficient to reduce microorganisms to an acceptably low level. High levels of terpenes and psychoactive chemical components are retained in the dried material.
- 10 One aspect of the invention provides a method of pasteurizing and dehydrating marijuana plant material, such as flower buds, leaves and stems, comprising the steps of: (a) loading the marijuana plant material into a vacuum chamber; (b) reducing pressure inside the vacuum chamber to a first pressure less than atmospheric (c) maintaining the marijuana plant materials in the vacuum chamber at the first pressure for a first time
- 15 period at a pasteurizing temperature while irradiating the marijuana plant material with microwave radiation; (d) reducing the pressure in the vacuum chamber after step (c) to a second pressure lower than the first pressure; (e) maintaining the marijuana plant material in the vacuum chamber at the second pressure for a second time period at a dehydrating temperature lower than the pasteurizing temperature while irradiating it with
- 20 microwave radiation to dehydrate it; and (f) unloading the pasteurized and dehydrated marijuana plant material from the vacuum chamber.

- Another aspect of the invention provides a continuous-throughput method of pasteurizing and dehydrating marijuana plant material, comprising the steps of: (a) reducing pressure
- 25 inside a first vacuum chamber to a first pressure less than atmospheric; (b) loading the marijuana plant material into the first vacuum chamber; (c) maintaining the marijuana plant material in the first vacuum chamber at the first pressure for a first time period at a pasteurizing temperature while irradiating it with microwave radiation; (d) unloading the pasteurized marijuana plant material from the first vacuum chamber; (e) reducing
- 30 pressure in a second vacuum chamber to a second pressure lower than the first pressure; (f) loading the pasteurized marijuana plant material into the second vacuum chamber; (g) maintaining the pasteurized marijuana plant material in the second vacuum chamber at the second pressure for a second time period at a dehydrating temperature lower than the pasteurizing temperature while irradiating it with microwave radiation to

dehydrate it; and (h) unloading the pasteurized and dehydrated marijuana plant material from the second vacuum chamber.

In some embodiments, the step of dehydrating precedes pasteurizing.

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An aspect of the invention provides a method of dehydrating and pasteurizing marijuana plant material, comprising the steps of: (a) loading the marijuana plant material into a vacuum chamber; (b) reducing pressure inside the vacuum chamber to a first pressure less than atmospheric; (c) maintaining the marijuana plant materials in the vacuum
10 chamber at the first pressure for a first time period at a dehydrating temperature while irradiating it with microwave radiation to dehydrate it; (d) increasing the pressure in the vacuum chamber after step (c) to a second pressure higher than the first pressure; (e) maintaining the marijuana plant material in the vacuum chamber at the second pressure for a second time period at a pasteurizing temperature higher than the dehydrating
15 temperature while irradiating it with microwave radiation; and (f) unloading the dehydrated and pasteurized marijuana plant material from the vacuum chamber.

Yet another aspect of the invention provides a method of dehydrating and pasteurizing marijuana plant material, comprising the steps of: (a) reducing pressure inside a first
20 vacuum chamber to a first pressure less than atmospheric; (b) loading the marijuana plant material into the first vacuum chamber; (c) maintaining the marijuana plant material in the first vacuum chamber at the first pressure for a first time period at a dehydrating temperature while irradiating the marijuana plant material with microwave radiation; (d) unloading the dehydrated marijuana plant material from the first vacuum chamber; (e)
25 reducing pressure in a second vacuum chamber to a second pressure higher than the first pressure; (f) loading the dehydrated marijuana plant material into the second vacuum chamber; (g) maintaining the dehydrated marijuana plant material in the second vacuum chamber at the second pressure for a second time period at a pasteurizing temperature higher than the dehydrating temperature while irradiating the dehydrated marijuana plant
30 material with microwave radiation; and (h) unloading the dehydrated and pasteurized marijuana plant material from the second vacuum chamber.

A further aspect of the invention provides an apparatus for pasteurizing and drying an organic material, such as marijuana plant material, comprising: (a) a first microwave-
35 vacuum unit, comprising: (i) a first vacuum chamber having an input end for introduction

of the organic material and an output end for removal of the organic material, (ii) a first conveyor for conveying the organic material from the input end to the output end, (iii) a first microwave source arranged to irradiate microwave energy into the first vacuum chamber, and (iv) a first vacuum source for reducing pressure inside the first vacuum chamber to a first pressure below atmospheric, (b) a second microwave-vacuum unit downstream of the first microwave-vacuum unit, comprising: (i) a second vacuum chamber having an input end for introduction of the organic material and an output end for removal of the organic material, (ii) a second conveyor for conveying the organic material from the input end to the output end, (iii) a second microwave source arranged to irradiate microwave energy into the second vacuum chamber, and (iv) a second vacuum source for reducing pressure inside the second vacuum chamber to a second pressure different from the first pressure; and (c) a conveyor for transferring the organic material from the output end of the first vacuum chamber to the input end of the second vacuum chamber.

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Further aspects of the invention and features of specific embodiments of the invention are described below.

Brief Description of the Drawing

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Figure 1 is a schematic diagram of a pasteurizing and drying apparatus according to one embodiment of the invention.

Detailed Description of the Preferred Embodiments

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The process of the invention pasteurizes and dries marijuana plant material using a microwave vacuum chamber. The plant material comprises parts of the plant containing terpenes and psychoactive components, and includes marijuana flower buds, leaves and stems. The process is useful and effective for all such marijuana plant material.

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Apparatuses for applying microwave radiation to organic materials in a vacuum chamber are known, and have conventionally been used in the food processing and pharmaceutical industries. They are disclosed, for example, in WO 2009/049409 (Durance et al.), WO 2011/085467 (Fu et al.), WO 2013/010257 (Fu et al.), and WO 2014/085897 (Durance et al.).

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In the present invention, the marijuana plant material is placed in the vacuum chamber and vacuum is applied to reduce the pressure to below atmospheric. The reduced pressure is selected such that the boiling point of water at that pressure is at a

5 temperature that the inventors have determined to be sufficient to pasteurize the marijuana plant material, i.e. reduce microorganism numbers to an acceptably low level, while not being significantly destructive to the terpenes and psychoactive compounds in the plant material. For example, the THC content may be reduced by not more than 5% and the terpene content by not more than 35%. The pasteurization pressure is

10 accordingly in the range of 150 to 400 Torr (200 to 533 mbar), alternatively 180 to 300 Torr (240 to 400 mbar), resulting in a pasteurization temperature in the range of 60 to 95°C, alternatively 62 to 88°C, alternatively 70 to 80°C, alternatively 65 to 80°C .

"Pasteurization temperature" means the temperature of the plant material during the pasteurization step. Microwave radiation is applied to the plant material during the

15 pasteurization step, and during the subsequent drying step, to heat the plant material and evaporate water. The pasteurization step is conducted for a time period in the range of 3 to 12 minutes, alternatively 3 to 10 minutes, alternatively 7 to 10 minutes. The inventors have determined that these pasteurization times and temperatures are sufficient to produce marijuana plant material that meets microbial regulatory standards, e.g., a total

20 plate count $\leq 50,000$ cfu/g, total yeast and mold ≤ 500 cfu/g, and bile tolerant gram negative bacteria (BTGN) < 100 cfu/g.

Immediately following the pasteurization step, the pressure in the vacuum chamber is reduced from the pasteurization pressure to a pressure corresponding to a drying

25 temperature that is lower than the pasteurization temperature and is sufficient to achieve drying of the plant material within a selected time period. For example, the drying pressure may be in the range of 10 to 60 Torr (13 to 80 mbar), alternatively 25 to 40 Torr (33 to 53 mbar), alternatively 25 to 35 Torr (25 to 47 mbar) Torr. The drying temperature may be in the range of 40 to 60°C. "Drying temperature" means the temperature of the

30 plant material during the drying step. At 40 Torr, the boiling point is 35°C, though the actual product temperature becomes somewhat higher than this due to presence of solutes in the water which are concentrated as water is evaporated off. The drying step is conducted at this reduced pressure and with microwave radiation heating the material, for a time period sufficient to reduce the water content of the material to a desired level.

35 For example, the drying time may be in the range of 20 to 30 minutes, alternatively 22 to

27 minutes, alternatively 15 to 25 minutes, and the final moisture level may be in the range of 8 to 14 wt.%. The term "drying time" as used herein does not include the time period for the pasteurization step.

- 5 The marijuana plant material may be moved within the vacuum chamber during the pasteurization and drying steps, for example by means of a rotating basket, a rotating tray rack, trays conveyed through the vacuum chamber, or a conveyor belt. This provides a more even exposure of the plant material to the microwave field within the chamber. The marijuana plant material may optionally be covered by a microwave-
- 10 transparent perforated cover during the pasteurization step and/or the drying step; this retains steam sufficiently to ensure a uniform marijuana temperature during the pasteurization step but allows steam to escape during the drying step.

- In the process as described above, the step of pasteurization is conducted before the
- 15 step of dehydration. This order is preferred, because the microbial population is more effectively reduced in plant material that is relatively moist. Nevertheless, it is possible carry out the process with the step of dehydration before the step of pasteurization. As shown in Example 2 below, which used this reverse order of the steps, the amount of reduction of Total Plate Count and of final yeast and mold count was less than where the
- 20 order was pasteurization followed by dehydration, as in Examples 1 and 3 to 6.

- According to an embodiment of the process in which dehydration is conducted before pasteurization, the marijuana plant material is loaded into the vacuum chamber and the pressure inside the vacuum chamber is reduced to a first pressure less than
- 25 atmospheric. The marijuana plant material is maintained in the vacuum chamber at the first pressure for a first time period at a dehydrating temperature while irradiating the marijuana plant material with microwave radiation to dehydrate it. The pressure in the vacuum chamber is then increased to a second pressure higher than the first pressure. The marijuana plant material is maintained in the vacuum chamber at the second
- 30 pressure for a second time period at a pasteurizing temperature higher than the dehydrating temperature while irradiating the marijuana plant material with microwave radiation. Finally, the dehydrated and pasteurized marijuana plant material is unloaded from the vacuum chamber. The pressures, temperatures and times for the steps of dehydration and pasteurization are the same as described above in respect of the
- 35 process in which pasteurization is conducted before dehydration.

The processes as described above can be conducted in a single microwave vacuum chamber, with the plant material being loaded into the vacuum chamber through an access port and unloaded at the end of the process, following repressurization of the chamber to atmospheric, from the same access port. Such apparatus is suitable for batch processing of the material.

According to another embodiment, the pasteurization and drying process is conducted on a continuous throughput basis rather than a batch basis. Figure 1 schematically illustrates a pasteurization and drying apparatus **20** that can be used for the continuous-throughput process. The same form of apparatus may be used both for the process in which pasteurization precedes dehydration and the process in which dehydration precedes pasteurization. The apparatus **20** comprises two microwave vacuum units, namely, a first unit **22** and a second, downstream unit **24**. The first microwave vacuum unit **22** comprises a first vacuum chamber **26** having an input end **28** for introduction of the material and an output end **30** for removal of the material. A first conveyor **32** conveys the material from the input end to the output end of the first vacuum chamber. A first microwave source **34** is arranged to irradiate microwave energy into the first vacuum chamber. A first vacuum source **36** is operatively connected to the first vacuum chamber for reducing pressure inside it to a first pressure below atmospheric. The second microwave vacuum unit **24** is arranged downstream of the first microwave vacuum unit. It comprises a second vacuum chamber **38** having an input end **40** for introduction of the material and an output end **42** for removal of the material. A second conveyor **44** conveys the material from the input end to the output end of the second vacuum chamber. A second microwave source **46** is arranged to irradiate microwave energy into the second vacuum chamber. A second vacuum source **48** is operatively connected to the second vacuum chamber for reducing pressure inside it to a second pressure different from the first pressure. The apparatus **20** has a conveyor **50** for transferring the organic material from the output end of the first vacuum chamber to the input end of the second vacuum chamber. The conveyor **50** may be at atmospheric pressure, so that the product is released to the atmosphere after treatment in the first unit **22**. Optionally, the conveyor **50** may include a vacuum lock so that the pasteurized product is maintained at reduced pressure between the pasteurization and drying steps. Optionally, the conveyors **32**, **44** may include means for rotating or tumbling the plant material. Optionally, the apparatus may include a microwave-transparent perforated cover for

covering the plant material. Where the apparatus **20** is used to carry out the process in which pasteurization precedes dehydration, the first unit **22** is the pasteurization unit, and the second, downstream unit **24** is the drying unit. Where the apparatus **20** is used to carry out the process in which dehydration precedes pasteurization, the first unit **22** is the drying unit, and the second, downstream unit **24** is the pasteurization unit.

The apparatus **20** includes components that are conventionally required for microwave-vacuum dehydrators, including condensers, refrigeration units, vacuum pumps, water loads, air locks and a programmable logic controller (PLC) for controlling the operation of the system, including controlling the conveyor drive motors, the microwave generators, the vacuum pumps and the refrigerant pumps.

The continuous-throughput process, in which pasteurization precedes dehydration, is carried out using the apparatus **50** as follows. The pressure inside the first vacuum chamber **26** is reduced to a first pressure less than atmospheric and the marijuana plant material is loaded into the first vacuum chamber. Optionally, the plant material may be covered by a microwave-transparent perforated cover. The marijuana plant material is maintained in the first vacuum chamber **26** at the first pressure for a first time period at a pasteurizing temperature while irradiating the marijuana plant material with microwave radiation as it is moved by the conveyor **32**. The pasteurized marijuana plant material is then unloaded from the first vacuum chamber via the conveyor **50**. It is fed into the second vacuum chamber **38**, having a second pressure lower than the first pressure. The pasteurized marijuana plant material in the second vacuum chamber is maintained at the second pressure for a second time period at a dehydrating temperature lower than the pasteurizing temperature while being moved through the second vacuum chamber and irradiated with microwave radiation to dehydrate it. Finally, the pasteurized and dehydrated marijuana plant material is unloaded from the output end **42** of the second vacuum chamber.

Similarly, the continuous-throughput process in which dehydration precedes pasteurization is carried out using the apparatus **50** as follows. The pressure inside the first vacuum chamber **26** is reduced to a first pressure less than atmospheric and the marijuana plant material, optionally covered, is loaded into the first vacuum chamber. The marijuana plant material is maintained in the first vacuum chamber **26** at the first pressure for a first time period at a drying temperature while irradiating the marijuana

plant material with microwave radiation as it is moved by the conveyor **32**. The dehydrated marijuana plant material is then unloaded from the first vacuum chamber via the conveyor **50**. It is fed into the second vacuum chamber **38**, having a second pressure higher than the first pressure. The pasteurized marijuana plant material in the
5 second vacuum chamber is maintained at the second pressure for a second time period at a pasteurizing temperature higher than the drying temperature while being moved through the second vacuum chamber and irradiated with microwave radiation. Finally, the dehydrated and pasteurized marijuana plant material is unloaded from the output end **42** of the second vacuum chamber.

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An example of a microwave-vacuum dehydrator that is suitable for use as the pasteurizing unit and as the drying unit is a resonant cavity-type microwave apparatus, as shown in WO 2009/049409 (Durance et al.), commercially available from EnWave Corporation of Vancouver, Canada, under the trademark nutraREV. Using this type of
15 apparatus, the marijuana plant material is placed for treatment in a cylindrical basket that is transparent to microwave radiation and has openings to permit the escape of moisture. The loaded basket is placed in the vacuum chamber with its longitudinal axis oriented horizontally. The pressure in the chamber is reduced. The microwave generator is actuated to radiate microwaves in the vacuum chamber and the basket is rotated within
20 the vacuum chamber, about a horizontal axis, so as to slowly and gently tumble the marijuana plant material during treatment. The rotation of the basket may be effected, for example, by means of rollers on which the basket is supported, or by means of a rotatable cage in which the basket is placed.

25 Another example of a microwave-vacuum dehydrator suitable for use as the pasteurizing unit and as the drying unit is a travelling wave-type apparatus, as shown in WO 2011/085467 (Durance et al.), commercially available from EnWave Corporation under the trademark quantaREV. The marijuana plant material is fed into the vacuum chamber and conveyed across a microwave-transparent window on a conveyor belt while being
30 subjected to low pressure and microwave radiation. With this type of apparatus, the marijuana plant material is processed while resting on a tray or the conveyor belt, and is not subjected to tumbling.

Examples

Example 1

A sample of marijuana flower buds was pasteurized and then dried using a microwave vacuum apparatus of the batch-processing type, having a microwave-transparent basket rotatable about a horizontal axis to tumble the material. A 0.5 kg sample having an initial moisture content of 80 to 84 wt.% and at a temperature of 20°C was loaded into the basket. The basket was placed in the vacuum chamber and rotated at 10 rpm. The vacuum chamber was evacuated to an absolute pressure of 180 Torr (240 mbar). Microwave power was applied at 1 kW for 5 minutes, at which point the marijuana flower bud temperature was 65 °C. The vacuum chamber pressure was then reduced to 30 Torr (40 mbar) for a further 22 minutes, at 1 kW of microwave power. The dried sample was removed from the vacuum chamber. Its temperature was 48°C and its moisture content was 11 wt.%. The product had a good structure. The operating parameters and test data are summarized in Table 1, below, for this and the following examples.

Example 2

A sample of marijuana flower buds was first dried and then pasteurized, using a microwave vacuum apparatus with rotary basket, of the type described in Example 1. A 0.5 kg sample having an initial moisture content of 80 - 84 wt.% and at a temperature of 20°C was loaded into the basket. The basket was placed in the vacuum chamber and rotated at 10 rpm. The vacuum chamber was evacuated to an absolute pressure of 30 Torr (40 mbar). Microwave power was applied at 1 kW for 22 minutes. The vacuum chamber pressure was then increased to 180 Torr (240 mbar) for a further 5 minutes at 1 kW power. The dried sample was removed from the vacuum chamber. Its temperature was 54°C and its moisture content was 12 wt.%. The operating parameters and test data are set out in Table 1. The reduction of TPC and final yeast and mold was less than in Example 1. The product had a satisfactory structure.

Example 3

A 0.5 kg sample of marijuana flower buds was first pasteurized and then dried using a microwave vacuum apparatus with rotary basket, of the type described in Example 1. The operating parameters and test data are set out in Table 1. The finished product had a compressed structure.

Example 4

A 4 kg sample of marijuana flower buds was first pasteurized and then dried using a microwave vacuum apparatus with rotary basket, of the type described in Example 1. The operating parameters and test data are set out in Table 1. The finished product had a satisfactory structure.

Example 5

A 4 kg sample of marijuana flower buds was first pasteurized and then dried, using a microwave vacuum apparatus with a rotatable rack holding eight trays. No covers were put over the trays. The rotation of the rack moved the trays (which remained horizontal) about the interior of the vacuum chamber during the pasteurization and drying process. A 4 kg sample having an initial moisture content of 80 – 84 wt.% and at a temperature of 20°C was loaded onto the trays, at 0.5 kg per tray. The tray dimensions were 8.75 in. (21.9 cm) X 27.25 (68 cm) x 2.25 (5.6 cm) (LxWxH). The operating parameters and test data are set out in Table 1. The finished product had a satisfactory structure.

Example 6

A 4 kg sample of marijuana flower buds was first pasteurized and then dried, using a microwave vacuum apparatus with trays, of the type described in Example 5. The operating parameters and test data are set out in Table 1. The trays were covered with microwave transparent plastic covers, which were perforated sufficiently to allow steam to escape during the dehydration step but closed enough to retain enough steam to ensure a uniform marijuana temperature during the pasteurization step. The holes were approx. ½ inch in diameter and located every 2 inches across the width of the tray as well as along the tray length. The surface area of the holes was approximately 6.5 sq. inches (41.9 cm²). The tray rack was placed in the vacuum chamber and rotated at 10 rpm. The vacuum chamber was evacuated to an absolute pressure of 300 Torr (400 mbar). Microwave power was applied at 5 kW for 10 minutes, at which point the product temperature was 75°C. The vacuum chamber pressure was then reduced to 30 Torr (40 mbar) for a further 27 minutes, at 5 kW of microwave power. The dried sample was removed from the vacuum chamber. Its temperature was 41°C and its moisture content was 8 wt.%. The addition of plastic covers resulted in a greater reduction in Total Plate Count than was observed in Example 5 without plastic covers. The finished product had an excellent structure.

Table 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Microwave power (kW)	1	1	1	5	5	5
Rotation speed (rpm)	10	10	10	10	10	10
Pasteurization pressure (Torr)	180	180	300	300	300	300
Pasteurization time (min)	5	5	3	10	10	10
Pasteurization maximum temperature (°C)	65	65	75	75	75	75
Drying pressure (Torr)	30	30	30	30	30	30
Drying time (min)	22	22	22	27	27	27
Drying maximum temperature (°C)	48	54	55	60	45	41
Initial moisture (wt.%)	80 - 84	80 - 84	80 - 84	80 - 84	80 - 84	80 - 84
Final moisture (wt.%)	11	12	8	14	8	8
Initial TPC ¹ (cfu/g)	10,000 to 100,000	10,000 to 100,000	10,000 to 100,000	10,000 to 100,000	10,000 to 100,000	1,000,000
Final TPC ¹ (cfu/g)	270	730	<10	<10	<270	1.67 x 10 ³
Final yeast & mold (cfu/g)	370	690	20	<10	<320	N/A
Final BTGN ² (cfu/g)	N/A	N/A	N/A	<10	10 to <100	10 to <100 ⁵
Final terpene content (wt.%) ³	1.29	1.47	1.28	N/A	N/A	N/A
THC retention (%) ⁴	100	100	100	100	100	100

1. Total Plate Count.

2. Bile Tolerant Gram Negative bacteria.

5 3. The original terpene content was 1.5 to 2 wt.%.

4. Percent of initial tetrahydrocannabinol that was retained in the dehydrated marijuana flower buds.

5. The initial count was greater than 10⁴.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the following claims.

Claims

1. A method of pasteurizing and dehydrating marijuana plant material, comprising the steps of:

- (a) loading the marijuana plant material into a vacuum chamber;
- (b) reducing pressure inside the vacuum chamber to a first pressure less than atmospheric;
- (c) maintaining the marijuana plant material in the vacuum chamber at the first pressure for a first time period at a pasteurizing temperature while irradiating the marijuana plant material with microwave radiation;
- (d) reducing the pressure in the vacuum chamber after step (c) to a second pressure lower than the first pressure;
- (e) maintaining the marijuana plant material in the vacuum chamber at the second pressure for a second time period at a dehydrating temperature lower than the pasteurizing temperature while irradiating the marijuana plant material with microwave radiation to dehydrate it; and
- (f) unloading the pasteurized and dehydrated marijuana plant material from the vacuum chamber.

2. A method of pasteurizing and dehydrating marijuana plant material, comprising the steps of:

- (a) reducing pressure inside a first vacuum chamber to a first pressure less than atmospheric;
- (b) loading the marijuana plant material into the first vacuum chamber;
- (c) maintaining the marijuana plant material in the first vacuum chamber at the first pressure for a first time period at a pasteurizing temperature while irradiating the marijuana plant material with microwave radiation;
- (d) unloading the pasteurized marijuana plant material from the first vacuum chamber;
- (e) reducing pressure in a second vacuum chamber to a second pressure lower than the first pressure;
- (f) loading the pasteurized marijuana plant material into the second vacuum chamber;

(g) maintaining the pasteurized marijuana plant material in the second vacuum chamber at the second pressure for a second time period at a dehydrating temperature lower than the pasteurizing temperature while irradiating the pasteurized marijuana plant material with microwave radiation to dehydrate it; and

(h) unloading the pasteurized and dehydrated marijuana plant material from the second vacuum chamber.

3. A method according to claim 2, wherein the marijuana plant material is moved through the first vacuum chamber from an input end to an output end during step (c).

4. A method according to claim 2 or 3, wherein the pasteurized marijuana plant material is moved through the second vacuum chamber from an input end to an output end during step (e).

5. A method according to any one of claims 1 to 4, wherein the first pressure is in the range of 150 to 400 Torr.

6. A method according to any one of claims 1 to 4, wherein the first pressure is in the range of 180 to 300 Torr.

7. A method according to any one of claims 1 to 6, wherein the first time period is in the range of 3 to 12 minutes.

8. A method according to any one of claims 1 to 6, wherein the first time period is in the range of 3 to 10 minutes.

9. A method according to any one of claims 1 to 6, wherein the first time period is in the range of 7 to 10 minutes.

10. A method according to any one of claims 1 to 9, wherein the pasteurizing temperature is in the range of 60 to 95°C.

11. A method according to any one of claims 1 to 9, wherein the pasteurizing temperature is in the range of 62 to 88°C.

12. A method according to any one of claims 1 to 9, wherein the pasteurizing temperature is in the range of 70 to 80°C, alternatively in the range of 65 to 80°C.
13. A method according to any one of claims 1 to 12, wherein the second pressure is in the range of 10 to 60 Torr.
14. A method according to any one of claims 1 to 12, wherein the second pressure is in the range of 20 to 60 Torr.
15. A method according to any one of claims 1 to 12, wherein the second pressure is in the range of 25 to 40 Torr.
16. A method according to any one of claims 1 to 15, wherein the second time period is in the range of 20 to 30 minutes.
17. A method according to any one of claims 1 to 15, wherein the second time period is in the range of 22 to 27 minutes.
18. A method according to any one of claims 1 to 15, wherein the second time period is in the range of 15 to 25 minutes.
19. A method according to any one of claims 1 to 18, wherein the dehydrating temperature is in the range of 40 to 60°C.
20. A method according to any one of claims 1 to 19, wherein the pasteurized and dehydrated marijuana plant material has a moisture content in the range of 8 to 14 wt. %
21. A method according to any one of claims 1 to 20, wherein the method reduces bacterial numbers to a total plate count $\leq 50,000$ cfu/g, total yeast and mold ≤ 500 cfu/g, and BTGN < 100 cfu/g.
22. A method according to any one of claims 1 to 20, wherein the method reduces bacterial numbers by at least 1.5 log.

23. A method according to any one of claims 1 to 22, wherein the pasteurized and dehydrated marijuana plant material has a total plate count of less than 270 cfu/g.
24. A method according to any one of claims 1 to 22, wherein the pasteurized and dehydrated marijuana plant material has a total plate count of less than 10 cfu/g.
25. A method according to any one of claims 1 to 24, wherein the pasteurized and dehydrated marijuana plant material has a yeast and mold count of less than 100 cfu/g.
26. A method according to any one of claims 1 to 24, wherein the pasteurized and dehydrated marijuana plant material has a yeast and mold count of less than 10 cfu/g.
27. A method according to any one of claims 1 to 26, wherein the pasteurized and dehydrated marijuana plant material has a BTGN count of less than 100 cfu/g.
28. A method according to any one of claims 1 to 26, wherein the pasteurized and dehydrated marijuana plant material has a BTGN count of less than 10 cfu/g.
29. A method according to any one of claims 1 to 28, wherein the method reduces terpene content of the marijuana plant material by not more than 35%.
30. A method according to any one of claims 1 to 29, wherein the method reduces THC content of the marijuana plant material by not more than 5%.
31. A method according to any one of claims 1 to 29, wherein the pasteurized and dehydrated marijuana plant material has a THC content equal to the THC content of the original marijuana plant material.
32. A method according to any one of claims 1 to 31, further comprising the step of covering the marijuana plant material with a microwave-transparent perforated cover during the first time period.
33. A method according to any one of claims 1 to 32, wherein the marijuana plant material comprises marijuana flower buds.

34. A method according to any one of claims 1 to 32, wherein the marijuana plant material comprises marijuana leaves or stems.

35. A method of dehydrating and pasteurizing marijuana plant material, comprising the steps of:

- (a) loading the marijuana plant material into a vacuum chamber;
- (b) reducing pressure inside the vacuum chamber to a first pressure less than atmospheric;
- (c) maintaining the marijuana plant material in the vacuum chamber at the first pressure for a first time period at a dehydrating temperature while irradiating the marijuana plant material with microwave radiation to dehydrate it;
- (d) increasing the pressure in the vacuum chamber after step (c) to a second pressure higher than the first pressure;
- (e) maintaining the marijuana plant material in the vacuum chamber at the second pressure for a second time period at a pasteurizing temperature higher than the dehydrating temperature while irradiating the marijuana plant material with microwave radiation; and
- (f) unloading the dehydrated and pasteurized marijuana plant material from the vacuum chamber.

36. A method of dehydrating and pasteurizing marijuana plant material, comprising the steps of:

- (a) reducing pressure inside a first vacuum chamber to a first pressure less than atmospheric;
- (b) loading the marijuana plant material into the first vacuum chamber;
- (c) maintaining the marijuana plant material in the first vacuum chamber at the first pressure for a first time period at a dehydrating temperature while irradiating the marijuana plant material with microwave radiation to dehydrate it;
- (d) unloading the dehydrated marijuana plant material from the first vacuum chamber;
- (e) reducing pressure in a second vacuum chamber to a second pressure higher than the first pressure;
- (f) loading the dehydrated marijuana plant material into the second vacuum chamber;

(g) maintaining the dehydrated marijuana plant material in the second vacuum chamber at the second pressure for a second time period at a pasteurizing temperature higher than the dehydrating temperature while irradiating the dehydrated marijuana plant material with microwave radiation; and

(h) unloading the dehydrated and pasteurized marijuana plant material from the second vacuum chamber.

37. A method according to claim 36, wherein the marijuana plant material is moved through the first vacuum chamber from an input end to an output end during step (c).

38. A method according to claim 36 or 37, wherein the pasteurized marijuana plant material is moved through the second vacuum chamber from an input end to an output end during step (e).

39. A method according to any one of claims 35 to 38, wherein the second pressure is in the range of 150 to 400 Torr.

40. A method according to any one of claims 35 to 38, wherein the second pressure is in the range of 180 to 300 Torr.

41. A method according to any one of claims 35 to 39, wherein the second time period is in the range of 3 to 12 minutes.

42. A method according to any one of claims 35 to 39, wherein the second time period is in the range of 3 to 10 minutes.

43. A method according to any one of claims 35 to 39, wherein the second time period is in the range of 7 to 10 minutes.

44. A method according to any one of claims 35 to 43, wherein the pasteurizing temperature is in the range of 60 to 95°C.

45. A method according to any one of claims 35 to 43, wherein the pasteurizing temperature is in the range of 62 to 88°C.

46. A method according to any one of claims 35 to 43, wherein the pasteurizing temperature is in the range of 70 to 80°C, alternatively in the range of 65 to 80°C.
47. A method according to any one of claims 35 to 46, wherein the first pressure is in the range of 10 to 60 Torr.
48. A method according to any one of claims 35 to 46, wherein the first pressure is in the range of alternatively 20 to 60 Torr.
49. A method according to any one of claims 35 to 46, wherein the first pressure is in the range of 25 to 40 Torr.
50. A method according to any one of claims 35 to 49, wherein the first time period is in the range of 20 to 30 minutes.
51. A method according to any one of claims 35 to 49, wherein the first time period is in the range of 22 to 27 minutes.
52. A method according to any one of claims 35 to 49, wherein the first time period is in the range of 15 to 25 minutes.
53. A method according to any one of claims 35 to 52, wherein the dehydrating temperature is in the range of 40 to 60°C.
54. A method according to any one of claims 35 to 53, wherein the dehydrated and pasteurized marijuana plant material has a moisture content in the range of 8 to 14 wt. %
55. A method according to any one of claims 35 to 54, wherein the method reduces bacterial numbers to a total plate count $\leq 50,000$ cfu/g, total yeast and mold ≤ 500 cfu/g, and BTGN < 100 cfu/g.
56. A method according to any one of claims 35 to 54, wherein the method reduces bacterial numbers by at least 1.5 log.

57. A method according to any one of claims 35 to 56, wherein the dehydrated and pasteurized marijuana plant material has a total plate count of less than 270 cfu/g.

58. A method according to any one of claims 35 to 56, wherein the dehydrated and pasteurized marijuana plant material has a total plate count of less than 10 cfu/g.

59. A method according to any one of claims 35 to 58, wherein the dehydrated and pasteurized marijuana plant material has a yeast and mold count of less than 100 cfu/g.

60. A method according to any one of claims 35 to 58, wherein the dehydrated and pasteurized marijuana plant material has a yeast and mold count of less than less than 10 cfu/g.

61. A method according to any one of claims 35 to 59, wherein the dehydrated and pasteurized marijuana plant material has a BTGN of less than 100 cfu/g.

62. A method according to any one of claims 35 to 59, wherein the dehydrated and pasteurized marijuana plant material has a BTGN of less than 10 cfu/g.

63. A method according to any one of claims 35 to 62, wherein the method reduces terpene content of the marijuana plant material by not more than 35%.

64. A method according to any one of claims 35 to 63, wherein the method reduces THC content of the marijuana plant material by not more than 5%.

65. A method according to any one of claims 35 to 63, wherein the dehydrated and pasteurized marijuana plant material has a THC content equal to the THC content of the original marijuana plant material.

66. A method according to any one of claims 35 to 65, further comprising the step of covering the marijuana plant material with a microwave-transparent perforated cover during the second time period.

67. A method according to any one of claims 35 to 66, wherein the marijuana plant material comprises marijuana flower buds.

68. A method according to any one of claims 35 to 66, wherein the marijuana plant material comprises marijuana leaves or stems.
69. An apparatus (20) for pasteurizing and drying an organic material, comprising:
- (a) a first microwave-vacuum unit (22), comprising:
 - (i) a first vacuum chamber (26) having an input end (28) for introduction of the organic material and an output end (30) for removal of the organic material;
 - (ii) a first conveyor (32) for conveying the organic material from the input end to the output end;
 - (iii) a first microwave source (34) arranged to irradiate microwave energy into the first vacuum chamber;
 - (iv) a first vacuum source (36) for reducing pressure inside the first vacuum chamber to a first pressure below atmospheric;
 - (b) a second microwave-vacuum unit (24) downstream of the first microwave-vacuum unit, comprising:
 - (i) a second vacuum chamber (38) having an input end (40) for introduction of the organic material and an output end (42) for removal of the organic material;
 - (ii) a second conveyor (44) for conveying the organic material from the input end to the output end;
 - (iii) a second microwave source (46) arranged to irradiate microwave energy into the second vacuum chamber;
 - (iv) a second vacuum source (48) for reducing pressure inside the second vacuum chamber to a second pressure different from the first pressure; and
 - (c) a conveyor (50) for transferring the organic material from the output end of the first vacuum chamber to the input end of the second vacuum chamber.
70. An apparatus according to claim 69, wherein the conveyor (50) is at atmospheric pressure.
71. An apparatus according to claim 69, wherein the conveyor (50) is below atmospheric pressure.
72. An apparatus according to any one of claims 69 to 71, wherein the first pressure is higher than the second pressure.

73. An apparatus according to any one of claims 69 to 71, wherein the first pressure is lower than the second pressure.

74. An apparatus according to any one of claims 69 to 73, further comprising a microwave-transparent perforated cover adapted to cover the organic material.

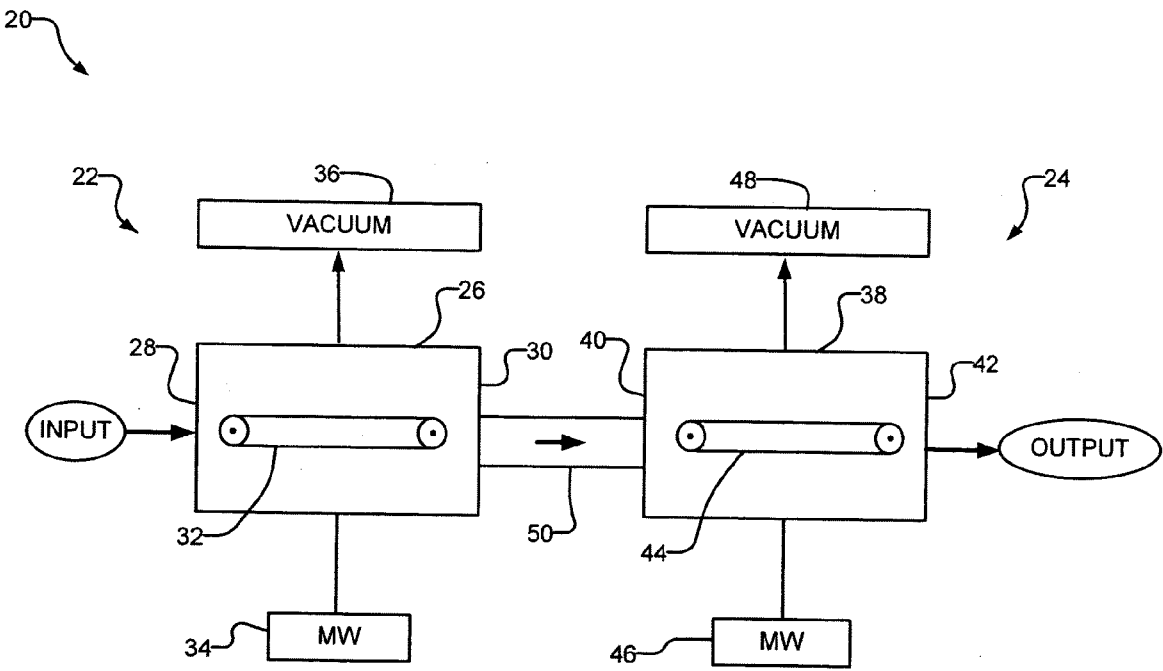


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2017/051025

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **A61L 2/12** (2006.01), **A61L 2/02** (2006.01), **F26B 17/02** (2006.01), **F26B 3/347** (2006.01),
F26B 7/00 (2006.01), **A23B 7/02** (2006.01) (more IPCs on the last page)

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)

IPC: **A61L 2/12** (2006.01), **A61L 2/02** (2006.01), **F26B 17/02** (2006.01), **F26B 3/347** (2006.01),
F26B 7/00 (2006.01), **A23B 7/02** (2006.01), **A23B 7/015** (2006.01), **A61K 31/352** (2006.01), **A61K 36/185** (2006.01)

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

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

Intellect (Canadian Patent Database) & Questel Orbit

Search terms: marijuana, pasteurizing, first pressure, second pressure, temperature, microwave, dehydrating, dry, drying,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US5972397 A (DURANCE et al.) 26 October 1999 (26-10-1999) *whole document*	1-74
A	CA2184384 (SIEGMUND et al.) 11 July 1996 (11-07-1996) *whole document*	1-74
A	US6381873 B1 (PEREMYCHTCHEV et al.) 7 May 2002 (07-05-2002) *whole document*	1-74
A	US2005/0123435 A1 (CUTLER et al.) 9 June 2005 (09-06-2005) *whole document*	1-74
A	US8286366 B2 (PITTARI et al.) 16 October 2012 (16-10-2012) *whole document*	1-74

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"T" "X" "Y" "&"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family
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04 May 2018 (04-05-2018)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2017/051025

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INTERNATIONAL SEARCH REPORT

International application No.

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A23B 7/015 (2006.01), *A61K 31/352* (2006.01), *A61K 36/185* (2006.01)