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(54) **Foodstuff preparation**

(57) Solid foodstuffs, such as chips, are sterilised for subsequent aseptic packaging and non-refrigerated storage, by cooking or part-cooking in a hot fluid medium under an applied pressure such as to elevate the boiling point of water in the product to at least the minimum lethal temperature for the most harmful micro-organisms and spores that may be present. The fluid medium may be oil or fat in which the foodstuffs are submerged, or which is sprayed on the foodstuffs. The pressure is applied by a gaseous medium or hydraulic means.

GB 2 148 693 A

SPECIFICATION

Foodstuff preparation

This invention relates to processes for the preparation of foodstuffs in a manner suitable for subsequent storage of the processed foodstuffs under ambient temperature storage conditions, and to foodstuffs so prepared.

All foods, whether in their natural state or in a prepared state, i.e. cooked or otherwise converted from the natural state, deteriorate in the course of time. This is due usually to enzymic or microbiological action. Micro-organisms may be present in the natural product or, in the absence of suitable packaging or other means of protection, may reach the product from outside.

The classic form of packaging for foodstuffs, for long-term ambient temperature storage, involves the application of heat for a predetermined period of time, at a temperature suitable for destroying significant micro-organisms, and their spores, in the product. This application of heat does have the additional effect of partly cooking the food product in the container; and the applied heat may affect the colour, texture and flavour of the product adversely.

The metal can has been widespread for so long partly because, (provided the product is suitable, its preparation and processing are carried out correctly, and the integrity of the can itself is satisfactory) food can be stored for very long periods of time without significant deterioration in palatability, and almost indefinitely without any danger of toxicity arising.

Foods may be preserved by other methods for long term storage at ambient temperature. One such method is dehydration, in which the water is removed by a variety of processes (such as heating under vacuum or freeze drying). The product then contains insufficient water to support the metabolism of vegative cells of bacteria, yeasts and moulds; whilst the conditions are so adverse that the spores of these organisms are unable to germinate, even though they may be present in large numbers. These products are known in the trade as "dry goods", and may be packed in containers, which are not airtight. Examples include sugar and tea.

Not all foodstuffs can be preserved in this way. The drying process often removes volatile components which are essential elements of flavour profiles; whilst the quality of the finished product depends on its rehydration properties. Dehydrated meats, for example, always remain chewy and tough after rehydration.

There is (as is well known) a wide variety of foods which are particularly amenable to being packaged for storage under deep-freeze conditions for very long periods.

There is a wide variety of foods which are suitable to being packaged for storage under deep-freeze conditions for very long periods. Preservation is achieved by deep freezing due to the fact that such freezing inhibits the metabolism of all the organisms within the product, whether or not they cause the product to deteriorate. Such products may be packed in metal cans, but are more frequently packed in containers which are usually made of paperboard or plastics materials, or metal foils, or combinations of these materials.

Deep-frozen products have the advantage that it is not essential that they undergo severe heat processing before being frozen. The product, or the filled package, is usually quick-frozen, i.e. frozen over a very short period of time. In the case of raw products such as vegetables, quick-frozen food, when eventually thawed out for use, is substantially in the same fresh condition in which it was packed. In the case of pre-cooked foods of kinds that are suitable for deep-frozen storage, there is substantially no change in the condition of the product between the packaging and freezing operation and the thawing operation.

The principal disadvantage of freezing as a means of preservation is one of cost. Frozen conditions must be maintained during processing, and subsequently through storage, distribution, retailing and at the point of use until such time that they are going to be used. In practical terms this can be many months; in energy terms it is naturally relatively expensive. In addition the end product is frequently not in a convenient ready-to-use form until it has undergone length thawing.

Furthermore, some products are partly or fully cooked before being frozen, with the intention that, after being thawed, they merely required to be re-heated for immediate consumption, or re-heated in suitable conditions (for example by frying) in order to complete the cooking process.

The flavours and textures characteristic of canned food products have over the years proved acceptable to the consumer in respect of many such products. Nevertheless, changes in texture and flavour are unacceptable to some consumers, and there is an increasing climate of opinion against the use of artificial colouring matter and other additives. Furthermore, many food products are, for one reason or another, quite simply unsuitable for canning.

A solution, which is gaining popularity, to the problem of obtaining long-term storage of foodstuffs without the need for either metal cans with heat processing or continuous frozen storage, is the use of so-called "aseptic" packaging. In aseptic packaging systems, the food product is packed in pre-sterilised containers under sterile conditions; for example it may be loaded into the containers, and the latter closed and hermetically sealed, within an enclosure in which the atmosphere, consisting of a sterile gaseous medium, is maintained at a pressure slightly higher than the ambient pressure, so that the enclosure contains no gas but that which is sterile. The subsequent life of the pack before it deteriorates, (or possibly becomes toxic), depends of course on the effectiveness of the barrier properties of the container against ingress of air or of harmful organisms or their spores. However, with many food products, aseptic packs have a useful shelf-life not dissimilar from that

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

of equivalent frozen food packs, or even of the same products when canned and processed.

A principal advantage of aseptic packaging is that the aseptic pack can be stored in ambient conditions. The container may take any one of a number of forms, provided its barrier properties, mentioned above, are suitable for the application for which it is intended. Examples include various containers of plastics materials, and indeed metal cans.

Aseptic packaging presupposes that the product itself is sterile when loaded into the container. So far as food products are concerned, this implies that the food has been in some way processed, for example cooked or partly-cooked, in such a way that it remains for a long enough period of time at a lethal temperature to kill all vegetative cells and potential harmful and spoilage organisms.

Such processing, to be effective as far as sterilization is concerned, must be such as to ensure that a lethal temperature prevails throughout the product. In the case of liquids this is not difficult to achieve, but for solid products it can be more difficult. In general it is necessary to reach a temperature of the order of at least 110° C, and preferably higher, in order to ensure a satisfactory lethal effect on harmful and spoilage organisms.

One particular form of cooking or part-cooking is deep frying. It is inherent in the frying process that the frying medium (hereinafter referred to as "oil", which term is to be understood to embrace in practice all oils and fats suitable for deep frying purposes) is very hot. The hot oil rapidly causes the familiar hard crust or skin to form on the outside surface of the product, if the latter has not previously been given such a crust or skin such as batter. During the short time in which the product is immersed in the oil, the rate of heat transfer from the outside surface into the centre of the product is for most products insufficient to enable the centre to reach the same temperature as the oil. Indeed, were it to do so the product would in many cases be overcooked.

The internal temperature of the product is determined by the water within it. Thus under typical conditions of conventional deep frying, with the oil at a temperature usually in the approximate range 150° C to 200° C, the internal temperature of the product will only be able to increase above 100° C (212° F), i.e. the normal boiling point of water, at points from which the water has evaporated.

Thus in deep frying, conditions lethal to unwanted organisms, and such as to sterilise the product, can only arise if the product is, or becomes while immersed in the hot oil, completely free of water, or if it stays in the oil for a very long time. With conventional frying, this precludes sterilization for most products.

In a first aspect, the invention provides a process for the preparation of a solid food product, comprising the step of subjecting the product to immersion in a hot oil (as hereinbefore defined) under an applied pressure such as to elevate the boiling point of water to a value at least as great as the minimum temperature required to kill the most resistant spoilage and potentially harmful micro-organisms and spores in the product, the temperature of the fluid medium being at least as great as the elevated boiling point of water, and the conditions being maintained for at least a predetermined period of time sufficient to obtain substantially complete or commercially-acceptable sterilisation of the product.

In practice, the hot fluid medium is preferably oil (as hereinbefore defined), so that the process is then a frying process.

The process may be continued for only a sufficient period of time to ensure the required lethal effect on the organisms in the product, thus constituting, for products requiring a longer cooking time, a part-cooking process. It may if required be continued thereafter (with or without continued application of pressure) until the product is fully cooked.

The product must then be maintained under aseptic conditions. Under these conditions, it is allowed to cool to ambient temperature if desired. It is then packaged aseptically in a sterile container having microbiological barrier properties suitable for maintaining its contents in a sterile condition for the required useful life of the package.

The sterilization process according to the invention is performed in a pressure zone. This pressure zone may be a room or a closed vessel (hereinafter called the "reaction vessel"), provided with suitable pressurising means for applying and maintaining the pressure necessary for the process.

The apparatus being designed for use with oil as the hot fluid medium, the pressurising means preferably comprises means for introducing a gaseous medium into the enclosed reaction vessel under controlled pressure. Such gaseous medium may be air or nitrogen or another inert gas. The gas may accelerate oxidative changes in the oil which would affect cooking quality and subsequent shelf life of any product cooked therein. Instead of the overpressure being applied by gases, steam could be used. The pressure may also be supplied hydraulically.

The apparatus in which the process is performed includes the reaction vessel and preferably includes also loading means and unloading means (which may be one and the same) associated with the reaction vessel for introducing the product into the latter and removing it therefrom. This may be done in, for example, one of two ways, viz. by a continuous-flow batch system, or by an intermittent batch technique.

If the apparatus is adapted for continuous flow, it preferably comprises a pressure chamber having a first opening which is obturable (by a door or similar means) and which communicates with the atmosphere outside, and a second opening which is similarly obturable and which communicates with the interior of the reaction vessel. The pressure chamber has a control system for operating the doors alternately, so that the chamber functions as a pressure lock. In conjunction with the opening and closing of the doors, the control system for the pressure chamber may also be arranged to control suitable means for introducing the pressurising medium (air or other gas, or steam) into the pressure chamber and extracting it therefrom, so as (if required) to reduce or eliminate pressure fluctuations in the reaction vessel when its effective volume is increased or decreased as the door of the second opening is opened and closed.

Two pressure chambers may be provided, one at an inlet of the reaction vessel and the other at an outlet thereof. Alternatively, a single pressure chamber may be provided so that as one batch of product (a batch being defined as one or more pieces) is introduced into the pressure chamber or reaction vessel, another can leave at the same time.

According to the size and nature of the product, any suitable handling means may be provided for moving and carrying the product, and extending into or through the reaction chamber, and the pressure chamber or chambers if present. This may for instance comprise a continuously-moving conveyor, the batches of product, or containers for carrying them, being suspended from or supported on the conveyor.

With the above apparatus an intermittent batch method of loading and unloading the reaction vessel may be employed, whereby each batch remains stationary (awaiting entry to the pressure chamber; in the latter; in the reaction vessel; and so on) for the length of time required for a batch of product to remain in the reaction vessel.

In apparatus adapted for another form of intermittent batch technique, the reaction vessel is loaded with, and unloaded of, each batch of product at ambient pressure, and is pressurised and depressurised at the beginning and end, respectively, of the process performed on that batch. Such a vessel may have a loading hopper at the top, to enable a batch of product to fall under gravity into the vessel; and means for subsequently removing the processed batch by gravity from the bottom, such as a further hopper. If the hot fluid medium is oil, separate means must in such a case be provided, whereby the oil can be drained before the batch of processed product is removed. To this end, there is preferably provided a suitable hot oil recirculating system, which may usefully incorporate a suitable filter, so that the oil is clean of debris before the process is performed on the next batch of product. Alternatively to removal of the oil and product in a hot condition, they may be allowed to cool before being removed from the reaction vessel.

The reaction vessel may be adapted to contain a mass of hot oil in which the product is submerged during the process. Alternatively, if a hot oil recirculation system, such as is mentioned above, is provided, this may include one or more spray heads for spraying the hot oil on to the product. The use of the verb "immerse" herein, in the context of the product in the hot fluid medium of the process, is to be understood to denote submersion or spraying or both.

The temperatures that are lethal to most micro-organisms lie above 110° C. For most practical purposes temperatures in the range 110°C-150°C would be used. Temperatures above 150°C are more effective but unnecessarily high. Accordingly the pressure applied in the process according to the invention must be sufficient to elevate the boiling point of the water in the product to at least 110° C, and preferably much nearer to 150° C. The applied pressure is accordingly at least 6 pounds per square inch (41368 Pa) above ambient pressure. In order to obtain a water boiling temperature of 148° C (298° F), the applied pressure is 50 pounds per square inch (344738 Pa) above ambient. This latter value is a preferred value for the applied pressure.

The temperature of the hot fluid medium in which the product is immersed depends on the cooking requirements for the particular product concerned. In a frying process, the oil temperature is typically in the range 150° C to 200° C. However, it is possible with certain vegetable oils to achieve higher temperatures. Individual vegetable oils have different cooking characteristics and physical properties, whilst a very large number of blends can be produced from available pure oils, the boiling points of the blends showing considerable variation. The oil, and therefore the temperature of the process, can thus be selected with cooking, rather than sterilization, considerations in mind; provided that the temperature of the oil is at least as high as the elevated boiling point of water at the value of applied pressure chosen.

It will be realised that, by employing the process according to the invention, the use of deep freezing for the long-term preservation of cooked or partly-cooked food products which would otherwise deteriorate unacceptably (by allowing parasitic organisms, or organisms such as to cause food poisoning or spoilage, to propagate) is avoided. This has a number of advantages, for example reduced cost and elimination of changes in texture or colour due to freezing or frozen storage. The sterile products, if aseptically packed, may be stored for long periods, transported and marketed under ambient conditions, quite safely. The process may also be used to advantage with products (such as potato chips) for which conventional canning is for various reasons entirely unsuitable.

In a second aspect, the invention provides apparatus, for example as described above, for performing the process of the invention.

Food products sterilized by the said process are included within the scope of the invention.

An embodiment of the invention will be described below, by way of example only. The food product here chosen to illustrate the process is one which is found to be particularly suitable for the operation of the process, viz. potato chips.

The term "chips", as used herein, means potato pieces or reconstituted potato starches and powders, the pieces being deep-fried. Such a piece (whether before, during or after frying) is referred to as a "chip". In the cooked state, chips are sometimes called French fried potatoes.

Chips constitute one of a number of food products which have never been successfully canned commercially because they deteriorate in colour, texture and flavour. They are made on a large scale by suppliers who supply catering establishments, wholesalers and retail outlets. Chips are also made by manufacturers of frozen food, being packed by them and supplied to wholesalers and retail outlets. There is thus a very large market for chips which requires that they be capable of being warehoused, transported and stocked on the shelves of traders, sometimes for considerable periods of time, before reaching the final consumer. The chips are produced either in a raw state, or partially fried, or fully cooked and ready to be merely re-heated in an oven before being consumed. If supplied in the raw state, the chips may be blanched, i.e. subjected to boiling water or steam to inactivate spoilage enzymes. This also reduces initial bacterial loads. However, unless required for immediate use, the only reasonably satisfactory way of preserving chips for the purposes of storage, transport, display in a shop, or the like, is by deep freezing them. Thus, whether in the blanched, partly-cooked or oven-ready state, deep freezing is currently the universally standard method of preserving chips.

Unfortunately, even chips that have been frozen have a flavour, and often a texture, which is noticeably different from those of chips made from fresh potatoes and immediately fried and then eaten. More significantly from the point of view of industrial application, the energy used in freezing the chips and maintaining them in a frozen condition until required, and the need in many cases to provide suitable frozen-food carrying vehicles for their transport, increases the cost of the product quite considerably.

In the process now to be described, potatoes are cut into the form of raw chips in known manner, or made by reconstituting potato powder, and are loaded into a hopper of a cooking and sterilising apparatus. The hopper has a bottom door which, when closed, obturates with a pressure-tight seal an inlet opening in the top of a reaction vessel, which is in the form of a pressure vessel. The reaction vessel is provided with a bottom door for releasing the chips into a suitable receptacle contained within an aseptic enclosure, in which a sterile gas is maintained at a pressure slightly higher than ambient, the gas being introduced to the enclosure after having been suitably treated to render it microbiologically sterile.

The reaction vessel also has a reservoir for edible oil provided with a heater for heating the oil to a temperature of about 200° C. The reservoir has an oil outlet connected, through a pump, with a series of spray heads inside the reaction vessel. An oil inlet of the reservoir is connected through a filter, and a suitable device for separating water from the oil, with an oil drain in a lower portion of the reaction vessel, the oil drain being in this example above the level of the reservoir oil inlet so that oil can drain to the latter under gravity.

The apparatus further includes a pressurising system comprising a gas compressor, which is connected in circuit with the interior of the reaction vessel for the purpose of circulating compressed gas through the latter. The gas in this example is nitrogen, for which purpose the gas circuit is a closed circuit, having a suitable connection to a source of nitrogen through appropriate valving and pressure-regulating means.

Means are provided for adjusting and regulating the nitrogen pressure in the reaction vessel, the temperature of the oil delivered to the spray heads, and the period of time for which the oil pump operates. Preferably, interlocks are provided whereby the hopper door and the bottom door cannot normally be open simultaneously, or at all when the oil pump or compressor is operating. The gas circuit includes a condenser, upstream of the compressor, for the purpose of cooling the returning nitrogen and removing water and water-soluble impurities therefrom, and a filter for the removal of any solid particles entrained in the nitrogen gas.

In operation, when the hopper is full, its door is opened to release the batch of chips into the reaction vessel, whose bottom door is meanwhile in the closed position. The nitrogen compressor is started, pressurising the vessel to a predetermined value of 50 pounds per square inch (344738 Pa) above ambient. The oil in the reservoir is being maintained at the processing temperature. As soon as the nitrogen pressure reaches its predetermined value, the oil pump is started and run for three minutes, at the end of which time it is stopped. Whilst the pump is running, hot oil is sprayed liberally and continuously by the spray heads on to the chips, in such quantities and at such a rate as to ensure that all of the chips are immersed in the oil, throughout the three-minute period, at a temperature of approximately 200° C, thereby being fried. The oil drains back to the oil reservoir.

When the oil pump is switched off, the compressor is stopped and the lower door opened, so as to dump the now-cooked chips into the above-mentioned receptacle, which is removed by a conveyor or other suitable transfer means to an aseptic packaging facility, in which the batch of chips is loaded and sealed into a suitable sterile container or series of containers. The chips are allowed to cool and drain before being packed in the container or containers; but they are maintained under aseptic conditions at all times between leaving the reaction vessel and being sealed into the container.

The resulting packs are then subsequently stored and distributed at ambient temperatures, without being frozen. Upon reaching the ultimate user, they require only to be reheated in hot oil, hot air or by microwave heating, prior to being eaten. The period of time between the chips being packed and being eaten may be several weeks or even months.

During the immersion of the chips in the hot oil in the reaction vessel, the surface temperature of each chip is raised to approximately that of the oil. Due to the pressure applied by the compressed gas, the temperature of the water in the interior of each chip is increased by heat transfer from the oil up to a value of 148° C, but the temperature is prevented from increasing further by virtue of evaporation of the water. The process time chosen is far too short to give rise to any danger of the chip drying out. The interior of the chip is therefore itself at this temperature, so that by the end of the pre-determined period of time during which the chips are immersed in the hot oil, all significant micro-organisms in the chips, and their spores, are destroyed.

One possible end use for the chips is in automatic chip vending. Chip vending machines at present require to be replenished frequently with chips which have been frozen. The machine heats the chips by means of hot air or by re-frying them, and dispenses them to the consumer. Thus use of chips, prepared by a method such as is described above, in a vending machine, can reduce wastage and permit the chips to be stored for, and transported to, the machine without the need for refrigerated storage or transport.

CLAIMS

1. A process for preparing a solid food product containing water, including the step of immersing the

product in a hot fluid medium under an applied pressure such as to elevate the boiling point of water to at least the minimum temperature lethal to the most resistant harmful micro-organisms and spores in or characteristic of the product, the temperature of the medium being at least equal to the boiling point of water as thus elevated.

2. A process according to Claim 1, wherein the hot fluid medium is a deep-frying oil or fat.

3. A process according to Claim 1 or Claim 2, wherein the applied pressure is maintained at least sufficiently high to elevate the boiling point of water to the said minimum lethal temperature, whilst the temperature of the hot fluid medium is maintained at least at the boiling point of water as thus elevated, for a period long enough to obtain a predetermined degree of sterilisation of the product.

4. A process according to any one of Claims 1 to 3, wherein the said period is sufficient only for the product to be partly cooked.

5. A process according to any one of the preceding claims, wherein the product is separated from the hot fluid medium under aseptic conditions, and, while still under aseptic conditions, is hermetically sealed into a container.

6. A process according to Claim 3, when performed in a reaction vessel containing a gaseous medium, the pressure of the gaseous medium being the said applied pressure, the product being immersed for the said period in the hot fluid medium within the vessel.

7. A process according to Claim 6, wherein the gaseous medium is air.

8. A process according to Claim 6, wherein the gaseous medium is steam.

9. A process according to Claim 6, wherein the gaseous medium is substantially free of any oxidising agent.

10. A process according to any one of the preceding claims, wherein the applied pressure is at least 6 pounds per square inch (41368 Pa) above the prevailing ambient pressure.

11. A process according to Claim 10 wherein the applied pressure is 50 pounds per square inch (344,738 Pa) above the prevailing ambient pressure, the temperature of the fluid medium being at least 150 °C.

12. A process according to any one of Claims 6 to 11, comprising the steps of introducing the product into the reaction vessel, closing the vessel, introducing the gaseous medium so as to establish the applied pressure, drenching the product continuously with the hot fluid medium for the said period of time, and at the end of the period halting the supply of hot fluid medium and releasing the applied pressure.

13. A process according to Claim 3 or any one of Claims 6 to 12, wherein the said period of time is approximately 3 minutes.

14. A process according to any one of the preceding claims wherein the product is a vegetable product.

15. A process according to Claim 14, wherein the product consists of potato chips.

16. A process for preparing potato chips, when performed substantially as hereinbefore described.

17. A solid food product, when prepared by a process according to any one of the preceding claims so that it is free of harmful micro-organisms and spores at least to the extent of being safe to eat.

New claims or amendments to claims filed on 10th Jan. 1985.
Superseded claims: 1 to 17.

CLAIMS

1. A procešs for preparing a solid food product containing water, including the steps of; cooking the product in a hot fluid medium under an applied pressure chosen so as to elevate the boiling point of water to at least the minimum temperature lethal to the most resistant harmful micro-organisms and spores in or characteristic of the product, the temperature of the medium being at least equal to the boiling point of water as thus elevated; maintaining the said applied pressure and temperature for a period long enough to obtain a predetermined degree of steralisation of the product; separating the product from the hot fuid medium under aseptic conditions; and, while it is still under aseptic conditions, hermetically sealing the product into a container.

2. A process according to Claim 1, wherein the hot fluid medium is a deep-frying oil or fat.

3. A process according to any one of Claims 1 or 2, wherein the said period is sufficient only for the product to be partly cooked.

4. A process according to any preceding claim, when performed in a reaction vessel containing a gaseous medium, the pressure of the gaseous medium being the said applied pressure, the product being immersed for the said period in the hot fluid medium within the vessel.

5. A process according to Claim 4, wherein the gaseous medium is air.

6. A process according to Claim 4, wherein the gaseous medium is steam.

7. A process according to Claim 4, wherein the gaseous medium is substantially free of any oxidising agent.

8. A process according to any one of the preceding claims, wherein the applied pressure is at least 6 pounds per square inch (41368 Pa) above the prevailing ambient pressure.

9. A process according to Claim 8 wherein the applied pressure is 50 pounds per square inch (344,738 Pa) above the prevailing ambient pressure, the temperature of the fluid medium being at least 150 °C.

10. A process according to any one of Claims 4 to 9, comprising the steps of introducing the product into the reaction vessel, introducing the gaseous medium into the vessel, the vessel being closed, introducing the gaseous medium so as to establish the applied pressure, drenching the product continuously with the hot fluid medium for the said period of time, and at the end of the period halting the supply of hot fluid medium and releasing the product from the applied pressure.

11. A process according to any preceding claim wherein the said period of time is approximately 3 minutes.

12. A process according to any one of the preced-

ing claims wherein the product is a vegetable product.

13. A process according to Claim 12, wherein the product consists of potato chips.

14. A process for preparing potato chips or other shelf-stable vegetable product, when performed substantially as hereinbefore described with reference to Figure 1 of the drawings of this application.

15. A process for preparing a shelf-stable meat or fish product when performed substantially as hereinbefore described with reference to Figure 2 of the drawings of this application.

16. A process according to any one of the preceding claims when performed using apparatus substantially as hereinbefore described with reference to Figure 3 of the drawings of this application.

17. A solid food product, when prepared by a process according to any one of the preceding claims so that it is free of harmful micro-organisms and spores at least to the extent of being safe to eat.

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