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(54) Title: METHOD FOR COOKING SHELL EGGS AND LIQUID EGG PRODUCTS USING RADIO WAVES

(57) Abstract

A method of and apparatus for hard cooking egg products such as shell eggs and prepackaged liquid egg products utilizing high frequency radio waves.

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METHOD FOR COOKING SHELL EGGS AND LIQUID EGG PRODUCTS USING RADIO WAVES

Field of the Invention

The present invention relates to a method of hard cooking egg products utilizing high frequency radio waves. The egg product to be cooked is raw liquid egg, and may be in the form of a whole shell egg. Additionally, methods and apparatus of the present invention may be used to hard cook pre-packaged liquid egg products.

Background of the Invention

Hard cooking of poultry eggs in commercial quantities is used in preparing consumer food products such as egg salads, pickled eggs, and deviled eggs, as well as in providing individual hard-cooked eggs for sale to consumers. Methods of hard cooking eggs in the food industry using steam chambers or immersion in hot water are known. *See* Stadelman et al., Egg and Poultry-Meat Processing, Ellis Horwood Ltd., Chichester (England) 1988, pages 64-69. Problems with these methods of cooking can include the extrusion of albumen from cracked eggshells, discoloration of the albumen, and the presence of sulfide imparting a greenish color to the yolk surface due to overcooking.

Packaging of a uniform layer of albumen around a center core of egg yolk in a long cylindrical package, with subsequent hard cooking to produce "long eggs" for commercial use is also known (*see* Stadelman et al., Egg and Poultry-Meat Processing, Ellis Horwood Ltd., Chichester (England) 1988, page 74).

U.S. Patent No. 4,091,119 to Bach discloses a method and apparatus for uniform heating of a foodstuff for preservation using high-frequency electromagnetic fields. The foodstuff (in particular, a jam, marmalade or jelly) is located in a container open at its top, and two fields, one high frequency and another ultra-high frequency, are directed at different portions of the foodstuff container. Use of a high frequency field of between 1 - 300 MHz, used in conjunction with an ultra-high frequency field of between 300 MHz and 5GHz, is disclosed.

U.S. Patent No. 4,853,238 to Huang discloses a method for treating liquid egg white or liquid whole egg in order to extend the shelf-life of the liquid egg material. The liquid egg material is subjected to microwave energy while it flows in a conduit for a time sufficient to inactivate or destroy a sufficient amount of microorganisms in the material without significantly reducing the egg protein functionality of the material.

U.S. Patent No. 4,975,246 to Charm discloses a method and apparatus for pasteurizing and/or sterilizing heat-sensitive material using high-temperature, short-time heating to substantially destroy selected microorganisms without substantially affecting other desirable properties of the material. Heat-sensitive material, such as liquid egg product, is continually passed through a flow path, such as plastic tubing, subjected to microwave radiation to heat the material to a high temperature for a short period, and then rapidly cooled.

U.S. Patent No. 4,280,032 to Levinson discloses a container designed to allow cooking of unshelled eggs in ovens using microwave radiation. U.S. Patent No. 4,413,167 to Martel discloses a container which allows cooking of shell eggs or unshelled eggs in microwave ovens; the container

shields the eggs from microwaves and the eggs cook by conduction.

Summary of the Invention

Disclosed is a method of hard cooking a shell egg. The method comprises exposing a raw shell egg to high frequency radio waves sufficient to heat the egg to a predetermined temperature and holding the heated shell egg for a predetermined time before cooling the shell egg. The total thermal treatment received by the egg is sufficient to hard cook it.

Also disclosed is a method of hard cooking a prepackaged liquid egg product. The packaged egg product is exposed to high frequency radio waves sufficient to heat the packaged product to a predetermined temperature, then held at an elevated temperature for a predetermined time before cooling. The total thermal treatment of the product is sufficient to hard cook the liquid egg product.

An apparatus for hard cooking raw shell eggs placed in a liquid carrier medium is also disclosed. The apparatus comprises a loading tank for holding liquid carrier medium containing the egg products, a product line connected to the loading tank, flow means connected to the loading tank for establishing a product stream in the product line, a radiolucent conduit interposed in the product line, and a generator which generates high frequency radio waves. The generator is positioned so that radio waves generated pass through the radiolucent conduit and heat the egg products therein. Holding means are connected to the product line after the radiolucent conduit (relative to the direction of flow in the product line).

Also disclosed is an apparatus for hard cooking egg products, comprising conveying means for transporting egg products along a predetermined path, a generator for generating high frequency radio waves, and holding means for holding the egg products for a

predetermined time. The generator is positioned so that egg products on the conveying means are exposed to the high frequency radio waves generated by the generator.

Radio frequency energy has been reported as being used to scramble unshelled eggs (*See, e.g.*, "Magna-Tube" heat processing equipment sales brochure, Proctor Strayfield, Horsham, Pennsylvania), but has not heretofore been suggested for use in hard cooking of raw liquid egg products (shell eggs or prepackaged egg products). Advantages of high frequency radio waves for cooking liquid egg products include, among other things, rapid and uniform cooking of both yolk and albumen.

The foregoing and other objects and aspects of the present invention are explained in detail in the specification set forth below.

Brief Description of the Drawings

The **FIGURE** schematically illustrates an apparatus for carrying out an embodiment of the present invention.

Detailed Description of the Preferred Embodiments

As used herein the term shell egg refers to any avian egg which has not been removed from the original eggshell. As used herein the term hard cooking refers to cooking of liquid egg or liquid egg product to a firm and nonliquid state; it is what is more generally referred to as hard boiling. When shell eggs are used, hard cooking refers to cooking until both the albumen and yolk are firm and nonliquid; undercooking results in areas of liquid albumen or yolk. The term peeling as used herein refers to the removal of the eggshell from a cooked egg. As used herein, raw egg refers to liquid egg components (albumen and/or yolk) which have not been subjected to

any treatments to cause substantially cooked or coagulated egg components. For the purposes of the present invention, raw egg includes liquid egg products that have been pasteurized or otherwise treated, but which remain in an uncooked liquid state. As used herein, heated raw egg refers to liquid egg components that have been subjected to thermal treatments sufficient to raise the temperature of the liquid egg components, but insufficient to cause coagulation or cooking thereof. As used herein, liquid egg product refers to the liquid egg contained within a shell egg, as well as to unshelled combinations of liquid egg yolk and albumen which may contain additives such as sugar or salt, or may contain treated liquid egg components such as reduced cholesterol yolk.

Methods and apparatus of the present invention are suitable for hard cooking whole, raw shell eggs as well as raw liquid egg products contained in packages. Packaging may be in the form of single-serving consumer packages (for example, hard cooked restructured reduced-cholesterol eggs in individual consumer packages), or commercial packaging such as that used to produce 'long eggs' (*see below*). Discussions herein relating to the cooking of whole raw shell eggs are equally applicable to the cooking and use of prepackaged raw liquid egg products, including those in packages which impart a particular shape desirable for commercial purposes to the final cooked product (for example, tubular packages used to produce 'long eggs'; *see also* U.S. Patent No. 4,426,400 (use of mold to impart final form to cooked egg whites)). The contents of all U.S. patents referenced herein are specifically intended to be incorporated by reference herein in their entirety.

When using the methods and apparatus of the present invention to cook whole shell eggs, the shell eggs are preferably intact shell eggs, free of cracks,

breaks or punctures in the shell. Use of shell eggs with cracks or other imperfections in the shell may lead to extrusion of the albumen while cooking, and to defects in the final cooked egg (*e.g.*, torn albumen, exposed yolks, irregular or pitted albumen). Such imperfectly shaped cooked eggs are known in the art as salad grade, and are suitable for dicing or chopping; more uniformly shaped cooked eggs are referred to as top grade. Top grade cooked eggs are used, for example, in preparing pickled eggs, deviled eggs, and Scotch eggs.

As used herein, "prepackaged" egg products refers to liquid egg products that are removed from the shell and placed in packages prior to cooking with the present invention.

Liquid egg products suitable for hard cooking using the methods and apparatus of the present invention include shell eggs as well as prepackaged egg products comprising whole eggs, egg yolk, egg albumen, fortified whole egg (whole egg with added yolk), salt whole egg (e.g., salt 10%), sugar whole egg (e.g., sugar 10%), blends of whole egg with syrup solids, syrups, dextrose and dextrins and/or gums and thickening agents, blends of whole eggs with less than 1% sugar and/or salt, and reduced cholesterol egg products. Terms used herein have their standard meaning in accordance with industry and regulatory usage. *See, e.g.*, 7 C.F.R. § 59.570(b) (1985).

In cooking prepackaged raw liquid egg products using the method and apparatus of the present invention, any suitable packaging may be used which is radiolucent to the high frequency radio waves used in the present invention, which is not adversely affected by the cooking process, and which does not affect the quality of the final product. Examples of suitable packaging include, but are not limited to, glass, paper, treated cardboard and some plastics.

Prior to cooking shell eggs using the method and apparatus of the present invention, the eggs may be aged to alter the pH of the albumen in order to facilitate peeling of eggs after cooking. It is known that loss of carbon dioxide from the albumen during aging increases pH from about 7.6 in freshly laid eggs to about 8.9 after one to seven days. Aging facilitates peeling by loosening the bonding of the shell and shell membranes to the albumen. *See, e.g.,* Britton and Fletcher, *Poultry Science*, **65** (Suppl 1), 18 (1986); Stadelman and Rhorer, *Poultry Science*, **63**, 949 (1984).

It is recommended that the equivalent point method for evaluating thermal treatments be applied in practicing the present invention. This method describes the total thermal treatment received by a product in continuous flow equipment. Procedures for using the equivalent point method for analyzing the thermal effects on liquid products during continuous flow heating are outlined in Swartzel (1982), *J. Food Science*, 47, 1886; Swartzel (1986) *J. Agric. Food Chem.* 34, 397; U.S. Patent 4,808,425 to Swartzel et al., and are known to those skilled in the art.

The present invention utilizes that portion of the electromagnetic spectrum associated with radio reception (i.e., radio waves having a frequency of from about 500 Kilohertz (KHz) to about 110 Megahertz (MHz); or radio waves with wavelengths from about 1 meter to 10^4 meters). In particular, the present invention uses high frequency radio waves. As used herein, high frequency radio waves (HFRW) means electromagnetic radiation having a frequency of from about 15 MHz to about 150 MHz, or wavelengths of from about 2 meters to about 20 meters. Alternating currents generate electromagnetic waves of a desired frequency and wavelength, which travel at a speed characteristic of the medium in which they are traveling. The wavelength

(λ) of a particular wave in a given egg product is determined from a knowledge of the frequency f, which remains constant (a function of the generator), and v, which depends on the velocity of the wave in the product.

HFRW heating is distinguished from higher energy microwave heating in that it is a process that is generally easier to control as the input of energy, and hence heating, is not as rapid. Microwaves are that portion of the electromagnetic energy spectrum with frequencies of from 10^3 to 10^5 MHz. Additionally, larger capacity heating sections can be constructed for use with HFRW (i.e., the cross-sectional area of a HFRW heater can be larger than that used in microwave heating processes) as the penetration depth of HFRW energy is greater than that of microwave energy. It is a well-known phenomenon that as frequency increases, penetration of radio wave energy into matter decreases. The uniform heating of products provided due to the depth of radio wave penetration avoids the excessive surface heating that can occur using microwaves.

HFRW heating is distinguished from ohmic heating in that the heater design and controls are not dependent on the specific conductivity of the material being heated. For example, whole egg and scrambled egg mixes (whole egg with milk and salt) have sufficiently different electrical conductance that it is extremely difficult to heat them with the same ohmic heater. HFRW heating does not create free radicals and the resulting deterioration of flavor as is found when high energy ionizing radiation is used, for example, in pasteurizing egg products.

Any means for generating electromagnetic waves of the desired frequencies may be used to carry out the present invention. Any commercial or industrial generator capable of producing high frequency radio waves may be used. Examples of

suitable generators include RFC Model No. 930 (Radio Frequency Co., Inc., Millis, Massachusetts), or Magna-Tube heat processing equipment (Proctor Strayfield, Horsham, Pennsylvania). Generators may be added in parallel or in series to increase production or temperature. Generators may be harmonically suppressed or otherwise structured to meet standards for electromagnetic or radio frequency emissions. In a general embodiment of heating using HFRW, the product to be heated is situated between two electrode plates which are charged alternately positive and negative. The plates are connected to the radio frequency generator.

In the present method and apparatus, raw shell eggs or prepackaged raw liquid eggs or liquid egg products are passed through a cooking apparatus where they are exposed to HFRW, and receive thermal treatment sufficient to result in hard cooking of the product. The egg products to be cooked may be conveyed through the apparatus by any suitable means. Suitable conveying means include but are not limited to moving conveyer belts, rails or guides upon which eggs are moved, receptacles such as buckets which are moved through the cooking apparatus, and receptacles attached to conveyor belts. Such mechanical conveying means may be partially or wholly placed in liquid, or surrounded by air.

An additional means of conveying egg products through the cooking apparatus is by placing (i.e., partially or wholly immersing or submerging) the egg products in a liquid carrier medium so that they are flowable, i.e., able to be carried by the flow of the liquid carrier medium. When a liquid carrier medium is used as the conveying means it will be readily apparent to one skilled in the art that an adequate flow of liquid carrier medium through the apparatus must be produced, so that the egg products are conveyed through

the cooking apparatus at an adequate rate. Suitable means for producing a flow include but are not limited to gravity flow conduits and pumps such as SINE PUMPS® (Sine Pumps, N.V.), auger type pumps, or combinations thereof. Suitable liquid carrier media include water and saline, and may include sterilizing or other additives. It will further be apparent that when eggs are carried in a liquid carrier media the flow must be contained in a product line. Product lines are essentially watertight conduits made of any suitable material, such as stainless steel.

The apparatus of the present invention includes a loading area where egg products are placed on the conveying means. It is readily apparent that the loading area must be designed to complement the particular conveying means used. Exemplary loading areas include accessible sections of mechanical conveying means (e.g., accessible to humans or to automated egg transfer devices), and loading containers such as tanks or tubes which contain liquid carrier media into which egg products are placed.

Any suitable means for holding the liquid egg product at an elevated temperature for a predetermined period of time may be used. Suitable holding means include, but are not limited to, continuations of the product line or conveyor belt, holding tanks, and trays and other containers in which egg products are placed. The egg products may be surrounded by liquid during holding or liquid present during cooking may be drained away.

The raw liquid egg products to be cooked by the method and apparatus of the present invention may encapsulate, be encapsulated by, or be combined with, edible materials with cooking requirements similar to that of the egg products, or edible materials which will not be adversely affected by the methods of the present invention, and packaged. The resulting

packages can then be conveyed through the apparatus as discussed above.

In the present invention, high frequency radio waves (HFRW) are converted to heat as they interact with liquid egg products in shell eggs or prepackaged liquid egg products. Absorption of electromagnetic energy increases the kinetic energy of the molecules of the absorbing medium, and increases the temperature of the absorbing medium. The high frequency radio waves produce heat within the liquid egg products being treated, causing cooking (when the egg products are surrounded by a liquid, heat is also produced in the liquid, as discussed below). Microbial destruction occurs, as in other cooking methods, due to thermal effects. However, it is not yet established whether microbial inactivation is also due to athermal effects resulting from unknown interactions between biochemical constituents of microbes and an electromagnetic field. *See, e.g.*, Adey, *Biological effects of radio frequency electromagnetic radiation*, In: Electromagnetic Interaction with Biological Systems, Lin (Ed.)Plenum Press, New York, pp. 109-140 (1989).

In the present invention, cooking occurs by (1) heating the liquid egg product using HFRW and (2) holding the liquid egg product at a cooking temperature for a period of time. The total thermal treatment received by a unit of egg product is thus a combination of the energy absorbed while exposed to HFRW and the time held at a cooking temperature. It will be apparent to those skilled in the art that the extent of cooking may be controlled by either altering the amount of HFRW energy received by the egg product (either by increasing the energy of HFRW used, or by increasing the time exposed to HFRW) or by altering the time the egg product is held at cooking temperatures. The thermal treatment desired is typically insured by

presetting the holding times. The term "holding time" as used herein has its ordinary meaning as used in the industry.

When the egg products to be cooked are placed in a liquid, the liquid is heated by the HFRW. Cooking occurs due to both the absorption of HFRW energy by the egg product, as well as to heating of the egg products while held in the heated liquid.

To produce uniformly cooked egg products each unit of egg product must receive substantially the same thermal treatment as comparable units (as used herein, a unit of egg product refers to either a shell egg or to a package of liquid egg product). This can be accomplished by exposing each unit to the same HFRW energy and holding each unit for the same length of time prior to cooling, with other conditions being substantially uniform. For example, egg products carried on a moving conveyor belt may be spaced at regular intervals and passed through the radiolucent conduit at a uniform rate, then each unit held for a given time before being cooled. Alternatively, multiple units of egg product may be exposed to HFRW as a batch, then held for a given time and cooled as a batch. Similarly, egg products carried in a liquid carrier medium may be conveyed as a continuous flow or in batches.

An exemplary apparatus of the present invention for use in cooking egg products carried in a liquid carrier medium comprises a loading tank, a product line connected to the loading tank, an auger type pump for establishing a flow of liquid carrier medium in the product line, a radiolucent conduit interposed in the product line, a HFRW generator, and a holding section. Egg products to be cooked are carried through the apparatus in the product line, exposed to HFRW, and held for the time required to provide the degree of cooking desired. Egg products may be moved

through the apparatus as a continuous flow, or in batches. The loading area comprises a tank holding the liquid carrier medium and the egg products prior to entry into the product line, and is made of any suitable material (e.g., stainless steel). The auger type pump is operably attached to the loading tank and produces a product stream in the product line. The product line is an essentially water-tight conduit through which the liquid carrier medium containing the egg products is passed, and is connected to the radiolucent conduit. Exposure to HFRW occurs in the radiolucent conduit. The HFRW generator is positioned so that radio waves generated pass through the radiolucent conduit and the egg products therein.

An exemplary apparatus of the present invention for use in cooking egg products carried on a conveyor belt and not surrounded by liquid comprises a loading area, a conveyor belt moving along a predetermined path, an HFRW generator positioned so that radio waves generated pass through the egg products on the conveyor belt at a predetermined point, and a holding section. Egg products to be cooked are loaded onto the conveyor belt at the loading area, carried along the predetermined path by the conveyor belt, pass the HFRW generator and are exposed to HFRW, and are then held for the time required to provide the degree of cooking desired. Egg products may be moved through the apparatus at a continuous rate, or in batches. Portions of the apparatus may be made of material that is radiolucent to ensure adequate exposure of egg products to HFRW.

The above described apparatus are readily assembled from commercially available parts, or commercially available systems may be modified for use in the present invention. As an example, the THERMOFLO™ RF Heating System (Radio Frequency Co., Inc., Millis, Massachusetts), designed to use radio

waves to pasteurize liquid egg products, may be modified for use in the present invention by one skilled in the art.

As used herein, "radiolucent" means that the material is essentially transparent to radio waves of the frequency used in the method of the present invention; while the material may be permeable to electromagnetic waves of other frequencies, this is not required. The radiolucent components are preferably manufactured from a suitable synthetic plastics material. Examples of suitable materials include polytetrafluoroethylene (e.g., the product marketed as TEFLON™ or HOSTAFLON™), and polycarbonate resins such as LEXAN™.

After exposure to HFRW, egg products are held at elevated temperatures for a predetermined holding time to provide the desired total thermal treatment; egg products may then be cooled to refrigerated temperatures. The egg products may be undercooked after exposure to HFRW and prior to completion of holding. As used herein, "cooling" means decreasing the temperature of the egg product to refrigerated temperatures (<40°F). It will be readily apparent to one skilled in the art that many suitable methods of cooling are known in the art including, but not limited to, spraying with or immersion in cold water, exposure to cold air, use of chillers or refrigerators, and vacuum cooling. In addition, for those products suitable for freezing, cryogenic freezing or individual quick freezing (IQF) may be utilized.

Optional feedback control mechanisms may be incorporated into the apparatus of the present invention to control the total thermal treatment received by the egg products. Control of total thermal treatment may be accomplished by adjusting the HFRW energy, the rate of movement of egg products through the apparatus, the holding time, or combinations

thereof. Exemplary feedback mechanisms are based on temperature monitoring of the product after HFRW exposure. Temperature may be measured directly, e.g., by a temperature probe inserted into a unit of egg product, or indirectly such as by measuring the temperature of the liquid carrier medium and correlating this temperature to that of the HFRW heated egg product, or by use of an infrared thermometer to measure the surface temperature of the product and correlating this to the internal temperature. Feedback control may alternatively be based on methods of inspection, such as visual inspection.

One skilled in the art will be able, using routine experimentation, to determine the total thermal treatment required to cook an egg product to a desired degree. Using a feedback control mechanism, the treatment of multiple egg product may be controlled to provide substantially uniform cooking of individual units of egg products.

Using the method and apparatus of the present invention, it is possible to treat shell eggs from temperatures below 40°F (but above freezing), and prepackaged egg products from temperatures of freezing and below, up to cooking temperatures of about 195°F. Temperatures of above about 195°F have adverse effects on liquid egg, such as undesirable texture and color change.

An optional preheating step may be employed prior to HFRW cooking to preheat the raw liquid egg products and/or the liquid carrier medium. Heated raw egg is to be distinguished from hardcooked egg, in that heated raw egg has not undergone thermal treatment sufficient to cause significant coagulation or denaturation of the egg proteins. In general, heating of not more than about 155°F will warm liquid egg products without cooking thereof. Preheaters may be composed of, but are not limited to, conventional

heating systems such as plate, swept, tube heat exchangers, microwave heating systems, ohmic systems, steam injection, hot water injection, etc. It will be apparent to one skilled in the art that selection of the appropriate preheating system will depend on the product and apparatus being used. In an exemplary apparatus of the present invention in which egg products are surrounded by liquid, a Cherry-Burrell Model E SUPERPLATE™ preheater preheats the surrounding liquid to a temperature up to about 155°F prior to the egg products' exposure to and additional heating by HFRW.

An optional precooking step may be employed prior to HFRW cooking to precook the raw liquid egg products. As used herein, precooking refers to thermal treatment of raw egg which results in an outer layer of liquid egg product (egg white in the case of shell eggs) in the initial stages of coagulation, with the center portion of the egg product remaining liquid. In general, heating of not more than about 170°F will precook liquid egg products. Precookers may be composed of, but are not limited to, conventional heating systems such as plate, swept, tube heat exchangers, microwave heating systems, ohmic systems, steam injection, hot water injection, etc. It will be apparent to one skilled in the art that selection of the appropriate precooking system will depend on the product and apparatus being used. In an exemplary apparatus of the present invention in which egg products are surrounded by liquid, a Cherry-Burrell Model E SUPERPLATE™ preheater precooks the liquid egg product by raising the temperature of the egg product up to about 170°F, prior to the egg products' exposure to and additional cooking by HFRW.

The cooking apparatus may be sterilized at regular intervals to ensure sanitary conditions. Sterilizing may be accomplished by any suitable means

as is known in the art, such as by passing hot water under pressure through the apparatus so that hot water is contacted to those surfaces which contact the egg products or the liquid carrier medium, at a temperature and pressure and for a time sufficient to sterilize these surfaces.

When shell eggs are cooked, an optional mechanical peeler may be combined with the apparatus of the present invention to remove the eggshells after cooking. An optional final step is packaging the cooked egg products. Such packaging may include aseptic packaging. Aseptically packaged products are packaged to the exclusion of microorganisms other than those carried by the product itself. Also useful in carrying out this step is equipment which packages the product to the substantial exclusion of microorganisms, known in the industry as "clean fillers."

Hard cooked shell eggs may additionally be subjected to reheating after peeling in order to pasteurize them; reheating may take place prior to or after final packaging of the hard cooked eggs. For example, hard cooked eggs may be packed while still warm in a preservative solution, which may further be subject to retorting at various temperatures and pressures to pasteurize the product, as is known in the art. The use of radio frequency energy to create heat for pasteurization of whole hard cooked eggs is described in U.S. Patent 3,843,813 to Driggs.

An exemplary apparatus for carrying out the method of the present invention is shown schematically in the **FIGURE**. This apparatus is designed for use with egg products carried on a conveyor belt. Arrowheads indicate the direction of movement of the egg products. This apparatus is readily assembled from commercially available parts, or commercially available systems may be modified for use in the present invention. As an example, the THERMOFLO™ RF Heating System (Radio

Frequency Co., Inc., Millis, Mass.), designed to use radio waves to pasteurize liquid egg products, may be modified for use in the present invention by one skilled in the art.

The apparatus of the FIGURE comprises a loading area (**10**) through which a conveyor belt **(11)** passes. Shell eggs or prepackaged egg products are loaded onto the conveyor belt at the loading area. The conveyor belt moves the egg products from the loading area along a predetermined product path and past a HFRW generator **(14)**. A preheater **(12)** may optionally be located intermediate the loading tank and the HFRW generator. The HFRW generator **(14)** is positioned adjacent to the conveyor belt such that high frequency radio waves generated pass through the egg products. A holding section (**20**) consisting of an extended section of the conveyor belt is placed in the product path following the HFRW generator; the length of the holding section is chosen to provide the desired holding time to the egg product. A cooler (**24**) such as a chill tank or spray cooler optionally follows the holding section.

In use for carrying out a method of the present invention for cooking egg products the apparatus of the FIGURE may, for example, be configured so that HFRW having a wavelength of about 10 meters are generated and heat the egg products to cooking temperatures of from about 175°F up to about 195°F. The holding section is a length suitable to provide a holding time for the product up to about 30 minutes to thereby produce a cooked egg product. The temperature to which the egg product is heated and the holding time combine to produce a product with the desired degree of cooking. Those skilled in the art will recognize that different combinations of time and temperature may be used to reach the same result for a given product, and will further recognize that the desired combinations of

temperature and time will vary with the product being cooked.

Those skilled in the art will appreciate that minor variations can be made in the apparatus and procedures described herein without departing from the spirit of the present invention. Thus the invention is defined by the following claims, with equivalents of the claims to be included therein.

THAT WHICH IS CLAIMED IS:

1. A method of hard cooking a shell egg, comprising:

exposing a raw shell egg to high frequency radio waves sufficient to heat said raw shell egg to a predetermined temperature;

holding said heated shell egg for a predetermined time; and

cooling said shell egg;

wherein the total thermal treatment of said shell egg is sufficient to hard cook said shell egg.

2. A method according to claim 1, further comprising placing said raw shell egg in a liquid carrier medium prior to said exposing step.

3. A method according to claim 1, further comprising the step of preheating said shell egg to a temperature of up to about 155°F prior to said heating step.

4. A method according to claim 1, further comprising the step of precooking said shell egg by heating said shell egg to a temperature of up to about 170°F prior to said heating step.

5. A method according to claim 1, said radio waves having a frequency of from 15 MegaHertz to 150 MegaHertz.

6. A method according to claim 1, said radio waves having a wavelength of from about 2 meters to about 20 meters.

7. A method according to claim 1, said radio waves having a wavelength of about 10 meters.

8. A method of hard cooking a liquid egg product, comprising:

packaging raw liquid egg product;

exposing said packaged raw liquid egg product to high frequency radio waves sufficient to heat said packaged liquid egg product to a predetermined temperature;

holding said heated packaged egg product for a predetermined time; and

cooling said packaged egg product;

wherein the total thermal treatment of said product is sufficient to hard cook said liquid egg product.

9. A method according to claim 8, further comprising placing said packaged raw liquid egg product in a liquid carrier medium prior to said exposing step.

10. A method according to claim 8, wherein said liquid egg product comprises raw albumen and raw yolk.

11. A method according to claim 8, wherein said liquid egg product comprises reduced cholesterol raw yolk.

12. A method according to claim 8, further comprising the step of preheating said packaged liquid egg product to a temperature of up to about 155°F prior to said heating step.

13. A method according to claim 8, further comprising the step of precooking said packaged liquid egg product by heating said packaged liquid egg product to a temperature of up to about 170°F prior to said heating step.

14. A method according to claim 8, said radio waves having a frequency of from 15 MegaHertz to 150 MegaHertz.

15. A method according to claim 8, said radio waves having a wavelength of from about 2 meters to about 20 meters.

16. A method according to claim 8, said radio waves having a wavelength of about 10 meters.

17. An apparatus for hard cooking raw liquid egg products placed in a liquid carrier medium, comprising:

(a) a loading container for holding a liquid carrier medium containing raw liquid egg products;

(b) a product line connected to and in fluid communication with said loading tank;

(c) flow means connected to said loading tank for establishing a product stream in said product line, said product stream comprising liquid carrier medium containing egg products and flowing away from said loading tank;

(d) a radiolucent conduit interposed in said product line;

(e) a generator which generates high frequency radio waves, said generator operatively associated with said radiolucent conduit and positioned so that radio waves generated pass through said radiolucent conduit and heat the egg products contained in said product stream; and

(f) holding means for holding the heated egg products, said holding means operably connected to said product line after said radiolucent conduit, relative to the direction of flow in said product line.

18. An apparatus according to claim 17, further comprising a preheater connected to said product line before said radiolucent conduit, relative to the direction of flow in said product line.

19. An apparatus according to claim 17, further comprising a precooker connected to said product line before said radiolucent conduit, relative to the direction of flow in said product line.

20. An apparatus according to claim 17, further comprising a cooler operably connected to said product line after said holding section, relative to the direction of flow in said product line.

21. An apparatus according to claim 17, further comprising a mechanical egg peeler operably connected to said egg product line after said holding section, relative to the direction of flow in said product line.

22. An apparatus for hard cooking egg products, comprising:

(a) conveying means for transporting an egg product along a predetermined product path;

(b) a generator for generating high frequency radio waves, said generator operatively associated with said conveying means and positioned so that an egg product conveyed on said conveying means is exposed to high frequency radio waves generated by said generator; and

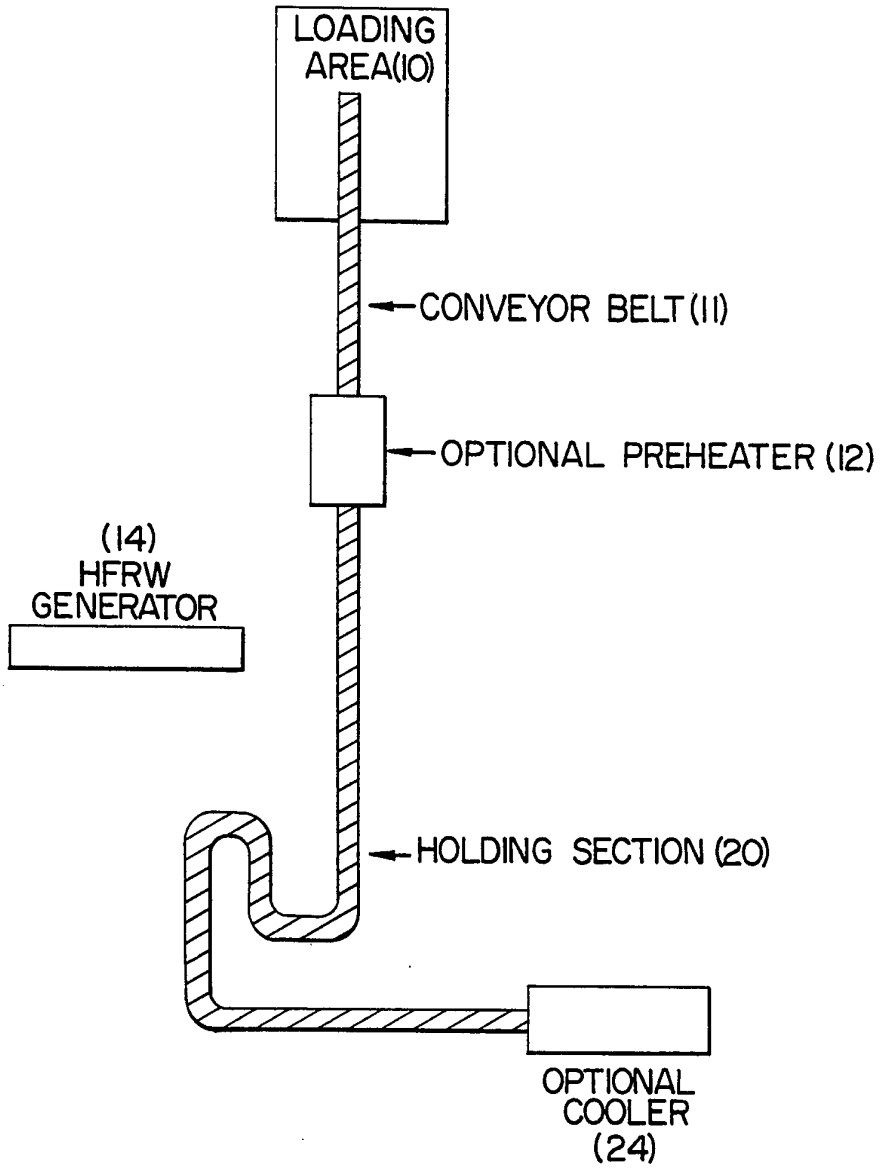
(c) holding means for holding the egg product for a predetermined time, said holding means operably connected to said conveying means for receiving the egg products and positioned after said generator, relative to the movement of the egg products along the product path.

23. An apparatus according to claim 22, further comprising a cooler operably connected to said holding means.

24. An apparatus according to claim 22, further comprising a preheater connected to said conveying means, said preheater positioned so that an egg product on said conveying means is preheated prior to exposure to high frequency radio waves.

25. An apparatus according to claim 22, further comprising a precooker connected to said conveying means, said precooker positioned so that an egg product on said conveying means is precooked prior to exposure to high frequency radio waves.

26. An apparatus according to claim 22, further comprising a mechanical egg peeler operably connected to said holding means.


LOADING AREA(10)
CONVEYOR BELT (11)
OPTIONAL PREHEATER (12)
(14) HFRW GENERATOR
HOLDING SECTION (20)
OPTIONAL COOLER (24)

INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/US 95/03302

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A23B5/005 A23B5/01

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 6 A23B A23L

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y Y Y	US-A-3 830 945 (HOWARD SCHARFMAN) 20 August 1974 see the whole document ---	1,3, 22-26 5-7 8,10,12, 13 17
Y	US-A-3 843 813 (L. W. DRIGGS) 22 October 1974 see the whole document ---	5-7
Y	FR,A,2 425 808 (S. TODA) 14 December 1979 see page 1, paragraph 1; claims; figures see page 5, line 35-38 --- -/--	8,10,12, 13

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" 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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 July 1995	21.07.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Guyon, R

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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/US 95/03302

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,3 398 251 (M. R. JEPPSON ET AL.) 20 August 1968 see the whole document	17
A	FR,A,2 100 352 (NUTIONICS MACHINE CORP.) 17 March 1972 see the whole document	1
A	FR,A,2 350 795 (J. BACK) 9 December 1977	
A	FR,A,2 107 423 (ALPHA-LAVAL) 5 May 1972	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internal Application No
PCT/US 95/03302

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-3830945	20-08-74	NONE		
US-A-3843813	22-10-74	BE-A-	769871	12-01-72
		CA-A-	1003268	11-01-77
		CH-A-	539395	14-09-73
		CH-A-	542592	30-11-73
		DE-A-	2133695	24-02-72
		FR-A-	2100352	17-03-72
		GB-A-	1326983	15-08-73
		GB-A-	1326984	15-08-73
		NL-A-	7108413	18-01-72
		US-A-	3764714	09-10-73
FR-A-2425808	14-12-79	NONE		
US-A-3398251	20-08-68	NONE		
FR-A-2100352	17-03-72	BE-A-	769871	12-01-72
		CA-A-	1003268	11-01-77
		CH-A-	539395	14-09-73
		CH-A-	542592	30-11-73
		DE-A-	2133695	24-02-72
		GB-A-	1326983	15-08-73
		GB-A-	1326984	15-08-73
		NL-A-	7108413	18-01-72
		US-A-	3843813	22-10-74
		US-A-	3764714	09-10-73
FR-A-2350795	09-12-77	DE-A-	2621312	01-12-77
		AT-B-	364232	12-10-81
		BE-A-	854563	01-09-77
		GB-A-	1583884	04-02-81
		JP-A-	53012448	03-02-78
		NL-A-	7705297	15-11-77
		US-A-	4091119	23-05-78
FR-A-2107423	05-05-72	CA-A-	957195	05-11-74
		CH-A-	551159	15-07-74
		DE-A-	2144732	31-05-72
		GB-A-	1357959	26-06-74

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna l Application No
PCT/US 95/03302

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-2107423		NL-A- 7112364	10-03-72
		US-A- 3809844	07-05-74