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(54) Title: PREPARING FAT-FREE FOOD PRODUCT USING HOT AIR IMPINGEMENT

(57) Abstract

A method and apparatus for preparing essentially fat-free strips or chips, such as potato chips and the like, having an appearance and taste similar to conventional strips or chips without the use of deep fat frying is disclosed herein. The method and apparatus includes exposing sliced raw potatoes and the like to a hot air fluid bed impingement oven arrangement that causes very rapid heating of the water contained in the chip and causes the chip to expand. The hot air fluid bed impingement oven arrangement preferably includes multiple dual-zone hot air fluid bed impingement ovens operating under different predetermined conditions. The slices are passed through each oven based on a desired conveyor belt speed and temperature range. The slices are then passed to a combination microwave and hot air dryer which removes entrained moisture without scorching the chips, thereby providing a lightly colored chip without a burned, overcooked taste and with an equalized moisture content. The resulting chip has an excellent mouth feel without the added fat associated with deep fat fried chip foods. Slices may be seasoned between exposure to the impingement oven arrangement and the microwave drying process.
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PREPARING FAT-FREE FOOD PRODUCT USING HOT AIR IMPINGEMENT

5 CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of Serial No. 08/756,275 filed November 25, 1996.

10 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to the art of making food products, and more specifically in one embodiment to a method and apparatus for making fat-free potato chips or strips using hot air impingement and in the case of potato chips, using a combination of hot air impingement and microwave/hot air drying.

Description of the Related Art

Food products such as French Fries, potato chips, corn chips, and tortilla chips are typically produced using hot oil. The manufacturer fries the potato strips or slices or tortilla slices in hot oil, which reduces the moisture content of the product. Subjecting these food products to hot oil results in a final product, for example potato chips, sometimes having a fat content of greater than 35 per cent by weight.

Today's health conscious consumer is looking for a low fat alternative to the traditional fried food product, and preferably a completely fat free product having minimal taste differences from the fried product. Different methods and means of preparing a fat-free chip have been employed in the past, including subjecting the chip to various processes which involve, at some stage of preparation, the application of a reduced amount of oil (see, e.g., Dreher et al., U.S. Patent No. 4,756,916, or Fazzolare et al., U.S. Patent No. 4,873,093), or subjecting the chips to a hot air impingement oven (see, e.g., Zussman, U.S. Patent No. 5,370,898) or subjecting the chips to one or more microwave processes (see, e.g., Kloos, U.S. Patent No. 4,906,483).

These prior art methods and devices each have their respective drawbacks. Subjecting chips to oil during processing increases the fat content of the final chip, which
is undesirable. Exposing the chip to conventional fluid bed impingement ovens does not guarantee that the moisture content for all slices will be at a proper level and generally results in at least part of the final yield containing a lower quality product, i.e. product having excessive moisture or burned product, which must then be reheated or discarded. In particular, impingement ovens have been known to overcook or burn over 60 per cent of the food. The only means available to reduce or eliminate this overcooking is to sacrifice production rates by reducing air temperatures, the amount of potatoes used in the process, or the amount of time the product resides in the oven. Utilizing any one of these steps tends to case harden the final chip, as the slow removal of water prevents the puffing which is desirable in chips.

Subjecting the chip to microwaving generally works with a limited amount of product, and maintaining a high quality over a large batch of potato slices can be difficult.

It is therefore an object of the current invention to provide a method and apparatus for producing reduced fat or fat-free food products, e.g. chip products and potato strip products having a significantly reduced oil content.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method and apparatus for preparing potato, corn, and other food products such as strips and chips that is fast, economical, and free of or has a reduced level of frying fat or oil absorption. The method and apparatus of the present invention includes preparing raw food, such as by washing, peeling, slicing or cutting, and/or tumble washing the raw food source. Preparation of the slices may also include being subjected to a high intensity air knife arrangement to remove surface moisture. The method and apparatus further includes exposing raw the food item, such as cut potatoes and the like, to a hot air fluid bed impingement arrangement that causes very rapid heating of the water contained in the product and causes the product to expand. The hot air fluid bed impingement arrangement preferably includes multiple dual-zone hot air fluid bed impingement ovens operating under different predetermined conditions. The food items preferably are passed through each oven based on a desired conveyor speed and temperature range for the desired final moisture content.
This method and apparatus provides food products that are fully cooked and are fat free since all the cooking is achieved through a hot air fluid bed impingement arrangement. No deep frying is necessary, and the finished food product has many and sometimes all of the characteristics of those cooked in fat or oil except for the fat content.

The cooked food product can then be processed in a number of desirable ways thereafter, such as microwave drying, freezing for subsequent packaging, flavor coatings or other processes. The further processing will depend upon the desired final product.

In one preferred embodiment, raw potatoes are processed into strips and heated and fully cooked through the hot air fluid bed impingement arrangement to produce fully cooked potato strips which can then be subsequently frozen and packaged for storage and/or shipment.

In another preferred form of the invention, raw potatoes are processed to form raw chips which are then heated and cooked in a hot air fluid bed impingement arrangement to produce fully or almost fully cooked potato chips. If the resulting chips are fully cooked and dry, the chips can then be packaged for shipment or storage. If the chips have a residual moisture content, they can then be processed in a microwave or hot air dryer, or both, to remove the residual moisture content. Alternatively, the chips can be passed through a seasoning or flavor step and apparatus and then subsequently dried.

In a preferred embodiment of the current invention, potato slices for making chips are exposed to two dual-zone hot air fluid bed impingement ovens, the first oven having a conveyor belt transporting slices through the oven at a speed of 2.5 to 3.0 feet per minute and operating at 500 to 525 degrees Fahrenheit (zone 1) and 450 to 500 degrees Fahrenheit (zone 2). The second oven of the preferred embodiment has a conveyor belt operating at a speed of 1.5 to 2.0 feet per minute and at 350 to 400 degrees Fahrenheit (zone 1) and 300 to 350 degrees Fahrenheit (zone 2). The dimensions of the second conveyor belt are such that the belt can accommodate the flow of slices received from the first conveyor belt, which travels at a faster speed. The first impingement oven of the preferred embodiment removes approximately 50 to 60 per cent of the moisture in each slice, while the second impingement oven of the preferred embodiment removes approximately 20 to 30 per cent of the remaining moisture.

The slices may then have oil and/or seasoning applied thereto, and are then passed to a combination microwave and hot air dryer which removes entrained moisture.
without scorching the chips. The combination microwave/convection step dries the chips and provides a lightly colored chip without a burned, overcooked taste and with an equalized moisture content. The resulting chip has an excellent mouth feel without the added absorbed fat associated with deep fat fried chip foods, and the entire process increases the yield associated with snack chip preparation by inhibiting burning while simultaneously reducing excess moisture.

Other objects, features, and advantages of the present invention will become more apparent from a consideration of the following detailed description and from the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow chart of the method in accordance with the present invention;

FIG. 2 shows the general interaction between elements of the line operation in accordance with the preferred embodiment of the current invention;

FIG. 3 is a cross sectional view of a dual-zone hot air fluid bed impingement oven as used with the current invention; and

FIG. 4 illustrates the microwave/convection heat drying unit used with the present invention.

FIG. 5 is a flow chart of the method and a schematic drawing of the apparatus in accordance with the process of the present invention.

FIG. 6 is a schematic and partial block diagram of freezing and packaging and inspection apparatus which can be used in accordance with a further aspect of the present invention.

FIG. 7 is a schematic of a conventional french fryer.

FIG. 8 is a block diagram of a method and apparatus for seasoning or flavoring potato strips prepared in accordance with the method and apparatus depicted in FIG. 5.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a method and apparatus for creating a food product such as potato chips and strips that has the flavor, texture, and appearance of a fried food product such as a potato strip or chip but without the high fat content resulting from subjecting the raw food to oil. The methodology of the present invention is suitable for the preparation of fat-free chips or strips made from a wide variety of grains, vegetables, fruits, and the like which can be cut or otherwise formed into well-known shapes such as strips, chips, wafers or other flat, generally thin, sliced-shaped portions. The methodology of the present invention is also suitable for preparation of a variety of products that are traditionally baked, such as crackers, biscuits, and the like. The term food product as used herein refers to food products which generally resemble conventional potato chips, French fries, wafers and the like, and the term raw product slice means any of the cut or formed slices comprising any of the items or materials described above. The term “strip” refers to any of the cut or formed strips comprising any of the items or materials described above.

Rice and corn can be manipulated into tortillas or other flat shapes and subjected to the current inventive process. For example, tortillas may be formed from water and corn flour, pressed or extruded, and then subjected to the current inventive steps. For clarity of explanation the present invention will be described in the context of preparing fat-free potato chips or strips, but it is to be understood by one of ordinary skill in the art that the invention may be practiced using other food products as disclosed above while still within the scope of the invention. Further, as used herein, the terms "slice" or "slices" do not only refer to sectioned raw fruits or vegetables, but also to pressed manipulated corn or flour products, such as biscuits, and the like.

A process and apparatus are described for making low fat food products from uncooked raw food or uncooked food preparations. The uncooked raw food could be potatoes, vegetables or naturally occurring foods. The uncooked food preparations could be such preparations as potato based combinations as potato crisps or potato puffs or preparations as corn meal for tortilla chips, corn chips and the like, formed or prepared into strips, disks or other forms for later processing such as by heating or cooking. The later processing could be any number of procedures, such as hot air cooking and/or drying, seasoning and/or drying, microwave heating and/or cooking, hot oil or hot fat.
dipping or reconstituting, and the like. In either situation of uncooked raw food or uncooked food preparations, the precursor element is uncooked food which is formed so that it becomes a raw food item. For example, in the case of potatoes, the raw food item could be potato slices for chips, potato strips for “fries”, or other potato configurations produced from raw potatoes by slicing, cutting or the like. Examples of uncooked food preparations include corn meal, potato preparations such as for “Tater Tots”, or in the case of corn meal preparations, corn chips, tortilla chips and the like. When the uncooked food becomes a raw food item, it will typically have at least one dimension with a substantially uniform dimension and a moisture content. In the case of potatoes for potato chips, the potato will be sliced to a uniform thickness, and the moisture content will be that of the original raw potato. In the case of potato strips for use in preparing “fries”, the potato strips will have a substantially uniform thickness and/or cross-sectional area, and a moisture content corresponding to the original raw potato. In the case of potato preparations such as “Tater Tots”, the raw food item will have a generally uniform diameter, and/or generally uniform length. The moisture content will conform to the standard and desired moisture content of that type of preparation. The moisture content may vary according to the desired ingredients of the preparation, and any future processing. In the case of corn preparations, the uniform dimension is typically a uniform thickness created by pressing, rolling or other processing of the corn meal preparation. The moisture content will be that generally accepted for such preparations, and again may vary according to the ingredients and the preparation, the future processing, and the like.

With that preliminary forming of the uncooked food into a raw food item, having a substantially uniform dimension and a moisture content, the food item is heated in a hot air fluid bed impingement oven before any other heating of the food item. The impingement ovens will remove at least a portion of the moisture from the food item to produce a food product. That food product may be a final food product ready for consumption without further processing, such as potato chips or tortilla chips, or may be an intermediate food product which will be later processed, such as potato strips, later reconstituted or heated in a French fry cooker.

The method in accordance with the one aspect of the current invention is illustrated in FIG. 1. As shown therein, raw unpeeled potatoes are washed and peeled in
The slices may be washed with an aqueous solution, such as tap water, by using a water bath immersion system or a spray system. This initial washing step cleans the exterior of the potatoes. After washing, the potatoes may be peeled by any conventional peeling means, including by hand or by readily available peeling machinery. The washed and peeled potatoes are then inspected for any irregularities in step 102, and unacceptable potatoes discarded or otherwise processed to recover acceptable product.

The washed and peeled potatoes are then sliced by a vegetable slicing device in step 103. The potatoes are sliced to a thickness of approximately 0.060 inches to 0.080 inches. Thinner slices tend to become too fragmented during subsequent steps, while thicker slices will not adequately "puff," i.e. exhibit beneficial "mouth feel" qualities associated with traditional fried food chip products. Commercially available slicing devices include the UrschellTM slicer, manufactured by Urschell in Valparaiso, Indiana.

After cutting, the slices are subjected to a tumble wash step 104 which extracts surface starch from the slices and reduces their overall stickiness so as to assist in separating slices during subsequent steps. It is to be noted that no surface coatings or layers are either required or desired on the exterior surfaces of the slices prior to the initial cooking step.

After the slices are tumble washed in step 104, they are distributed on a belt and any excess surface moisture is removed using conventional air-knife type air jets in step 105. Although surface moisture need not be removed from the exterior surfaces of the raw food slices, it has been determined that removal of surface moisture using air knives facilitates the subsequent cooking steps of the current invention. Air knives are a type of forced air current used to remove surface coatings. Air knives use heated jets of air that are directed from above and below the raw, freshly washed and sliced potato slices. These air currents are typically within a range of between about 150 and 250 degrees Fahrenheit, with a preferred temperature of about 185 to 190 degrees Fahrenheit. Typical flow rates for these hot air currents are between 50 and 60 cubic feet per minute, and the air knife step 105 further serves to distribute the slices evenly across the belt.

Referring to FIG. 1, the raw food items in the form of dried slices are then distributed onto a continuous conveyor belt in multiple layers and are transported
through two individual hot air fluid bed impingement ovens operating under separately controlled conditions in steps 106 and 107.

The general interaction of the elements used in line operation of a preferred embodiment of the current invention is illustrated in FIG. 2. FIG. 2 is not to scale. As shown therein, raw foods or raw food preparations are placed into a hopper 201. From the hopper 201, the raw food is passed to a washer 202 and then to peeler 203. Inspection may optionally take place at location 204, and after inspection the peeled items are passed to a screw conveyor mechanism 205 which regulates the flow of peeled product into the slicer 206. The slicer slices the peeled product, and the sliced product passes to tumble washer 207. Tumble washer 207 passes the washed slices via first conveyor belt 208 through air knives 209 and into first dual-zone fluid bed impingement oven 210. The first conveyor belt 208 then transports the partially cooked slices onto second conveyor belt 211, which passes the partially cooked slices through second dual-zone fluid bed impingement oven 212. The second conveyor belt 211 passes the cooked slices through tumbler 214 having atomizers 215 and 216 located therein for application of an oil coating and seasonings. After passing through tumbler 214, the product is passed to third conveyor belt 213, which transports slices through combination microwave/convection oven 217 for final drying, and the product is ready for packaging.

FIG. 3 illustrates a cross sectional view of first hot air impingement oven 210. A hot air fluid bed impingement oven arrangement is preferred for the present invention. A hot air fluid bed impingement oven uses heated air or steam discharged at high pressure through tubes 301 into an oven chamber. Multiple tubes 301 are used in typical impingement ovens, but for simplicity and clarity five tubes are shown in FIG. 3. The ovens include a pan portion 302 and first conveyor belt 208 running through the oven and carrying the slices 303. The first and second conveyor belts 208 and 211 for both the first and second impingement ovens are preferably constructed of perforated stainless steel and, as shown in FIG. 2, have a plurality of projections 304 which are substantially perpendicular to the perforated stainless steel conveyor belt. Each conveyor belt may be alternatively a belt coated with a nonstick layer, such as polytetrafluoroethylene, such as Teflon® synthetic resin polymer, a trademark of E.I. DuPont de Nemours & Co., Wilmington, Delaware. The first and second conveyor belts 208 and 211 move through each respective impingement oven at a different rate of speed, and thus between the first
and second impingement ovens, the partially cooked slices are passed from the first
conveyor belt 208 onto the second conveyor belt 211.

The ridges 304 of the conveyor belts 208 and 211 allow movement of the food
product through the ovens while suspended on a bed of air, while simultaneously
preventing the food product from "floating" into an adjacent region on each belt. The
hazards of slices "floating" from one area to another is that floating slices may remain in
the oven for a longer time, thereby overcooking the slice, or may stay in the oven a
shorter time, which would undercook the slice. The ridges 304 therefore act as barriers,
retainers or timing devices in conjunction with the belt movement to move the food
along each conveyor belt in the direction of travel, constraining the slices and ensuring
an even flow over the bed of air through each oven as a function of time. This constraint
while the slices are floating within each impingement oven provides an even fluidization
process, and results in a better overall finished product at this stage of processing.

The ridges 304 on the first conveyor belt 208 are preferably less than three inches
in height spaced approximately thirty inches apart, and all ridges on all conveyor belts
used herein span the full width of the conveyor belts. The ridges may be curved or
otherwise formed (such as in an inverted-V "trough" type shape) while still being within
the scope of the invention. The ridges 304 may also be higher or lower than that
mentioned above depending on the type of food and the height of the product when
distributed on each belt. As may be appreciated, the difference in speeds between the
two conveyor belts may require either longer spacing or higher ridges in the second
slower belt to accommodate the food product, as discussed in more detail below.

As shown in FIG. 3, each oven expels hot air or steam out of the tubes 301
downward and at a high velocity toward the slices 303 on the conveyor belt 208. The
expelled hot air is reflected back toward the tubes 301. The air may be dried and filtered
and reheated by a burner or other heating device. The reheated air is passed through the
tubes and reflected back, and this passing/reflection process is typically repeated multiple
times.

The flow of heated air or steam creates the bed of hot air which suspends the
layered slices 303 above the upper surface of each conveyor belt 208 and 211. The slices
303 typically bounce when they come in contact with the surface of the belt, and slices
may change orientation as they pass through the oven under these conditions.
The length of the tubes 301 is approximately 20 inches and each tube has a
diameter of approximately 1 inch, which can vary without being outside the scope of the
invention. Other types of fluid bed impingement ovens, such as those which expel air or
steam from the sides or bottom of the oven are also acceptable. Hot air or steam may
also be expelled from other arrangements besides the tubes shown in FIG. 3 while still
within the scope of the invention.

In the preferred embodiment, the slices are exposed to the two ovens at different
temperature ranges. Both impingement ovens 210 and 212 are approximately twenty
five feet in length. The first oven 210 uses a two-zone arrangement where the first zone
uses an air temperature of 500 to 525 degrees Fahrenheit. The second zone of the first
oven 210 operates at a temperature of between 450 and 500 degrees Fahrenheit. The
slices flow through the first oven at approximately 2.5 to 3.0 feet per minute. The slices
are separated by the high velocity air striking and circulating off the solid bottom plate of
the oven, i.e. air passes through the slices 203, through the perforated stainless steel belt
208, striking the bottom plate 305 of the oven, and passing back through the perforated
stainless steel belt 208 and through the slices 303. Alternatively, the air may strike a belt
coated with a non-stick material and cause the slices to rise by rebounding off this belt.

As the chips float through the first impingement oven, they are surrounded by the
approximately 500 degree Fahrenheit air causing a very rapid heating of the chip, thereby
causin the chip to expand, or "puff." The tumbling effect as the chip dries shapes the
chip in a similar manner to that of fat frying. The combination of the two zones of the
dual zone oven removes approximately 50 to 60 per cent of the total moisture, by weight,
from the slice. The result is therefore a slice having from 40 to 50 per cent of the original
moisture content of the slice, by weight.

The second dual-zone hot air fluid bed impingement oven 212 operates in a
similar manner to the first impingement oven 210 except at a reduced belt speed and at
reduced operating temperatures in both zones. The second conveyor belt 211 operates at
a speed of approximately 1.5 to 2.0 feet per minute. The second fluid bed impingement
oven 212 also operates using two zones, with the first zone having a temperature of
approximately 350 to 400 degrees Fahrenheit, and the second zone operating at
approximately 300 to 350 degrees Fahrenheit. Operating the second conveyor belt 211 at
a slower speed than the first conveyor belt 208 requires that the second belt have larger
dimensions, i.e. larger spacing between ridges and/or a larger bed depth to accommodate the increased product flow or the higher volume of product being delivered at the input of the first zone. Bed depth, or ridge height, is increased due to the reduced belt speed, as more product is distributed into a given zone, and the slower movement of the belt increases exposure time at a lower temperature. The second impingement oven 212 removes approximately 20 to 30 per cent of the remaining moisture, by weight. From the original slice, the first impingement oven 210 removes 50 to 60 per cent of the moisture of the slice, leaving 40 to 50 per cent of the original weight. Second impingement oven 212 removes 20 to 30 per cent of the remaining moisture, yielding at this stage a range of between 28 to 40 per cent of the original moisture by weight.

At the end of the dual-impingement oven exposure steps 106 and 107, the slices 303 generally have the appearance of conventional potato chips. However, the moisture content of a percentage of the slices may be too high, depending on temperature settings, flow rates and other parameters, resulting in a portion of the yield being in an unfinished state.

If desired, the chips in their present form are then transmitted to a rotating drum for seasoning in step 108. A light amount of canola oil and salt or other flavoring mix is applied to the tumbling potato chips in the rotating drum. Seasoning with oil at this stage of the process allows the cellular structure of the chip to expand, allowing equal distribution of the oil and seasonings over the chip surface. Application of oil at this cooked stage of the process has proven to enhance the taste of the chip, and the oil only lightly coats each chip. This differs from the immersion of raw slices into deep fat fryers, wherein oil is absorbed into the slice as the slice is fried. In the current cooked chip state, no significant oil absorption occurs. The oil coating becomes caramelized, thereby imparting fried flavor notes to the chip and enhancing overall mouth feel. The chips are salted or seasoned using an atomizer located within the tumbler.

After seasoning, or after the ovens if no seasonings are applied and more moisture is to be removed, the chips are passed to a combination microwave-hot air dryer in step 109 to further dry the chips. This final drying step may be advantageously accomplished by a low power multi-mode microwave drying unit. In the presently preferred embodiment suitable for preparing potato chips, a conventional microwave "baking unit" Model No. IV-60, available from MICRODRY INC. of Crestwood, Kentucky is
employed. This unit is typically 48 feet long and includes a microwave transparent conveyor belt which is 6 feet wide. The conveyor belt is disposed between two perforated stainless steel plates disposed parallel to one another so as to form a multi-mode microwave cavity. Microwaves are injected into this cavity through two waveguides disposed along the top of the cavity with apertures communicating between the waveguide and the cavity. Normally four 60 kilowatt microwave generators are coupled to the waveguide to provide a total power input of 240 kilowatts into the microwave cavity. The intensity of the microwave field within the MICRODRY baking unit is relatively low, typically on the order of 6 watts per square inch. The energy density is enough to dry the partially processed chips but does not cause the puffing and surface roughening that normally occurs upon exposure to a high intensity microwave process. The actual microwave energy density employed depends on the chip density desired within the baking unit and the rate of travel for chips through the unit. If a maximum travel rate is desired so as to optimize chip production, then the maximum 240 kilowatt power output would preferably be employed. As used herein, the term low intensity microwave field means a field intensity sufficient to induce these effects.

During this final microwave drying stage the moisture content is reduced to a final amount of approximately 2 to 4 per cent by weight. Typically the conveyor belt for the microwave moves at a rate of ten to fifteen feet per minute, providing an exposure time for the potato slices of between about 3.2 to 4.8 minutes. Hot air is injected into the microwave cavity at a temperature of about 200 to 225 degrees Fahrenheit at a rate of approximately 200 feet per minute. This temperature is just high enough to remove the evaporated water from the oven. The hot air movement prevents condensation within the drying cavity and contributes to the final crisping of the chips.

During this stage of the chip preparation process, the chips need not be arranged in a single layer to achieve satisfactory drying and, in the preferred embodiment, are arranged in layers on the third conveyor belt 213 of up to approximately 4 inches deep.

This microwave and hot air drying step removes entrained moisture without scorching the chips as is a normal result of excessive application of hot air. The resulting chips retain the light coloring desired by consumers.

Referring to FIG. 4, the MICRODRY baking unit 400 is shown adjacent to the second dual-zone hot air fluid bed impingement oven 212. Third conveyor belt 213 of
the baking unit 400 may be disposed slightly underneath an output end 401 of second
conveyor belt 211 to catch the chips 303 as they leave the second fluid bed impingement
oven 212. If desired, spraying units or atomizers 402 may be employed at this point to
add "barbecue" and similar flavorings to the chips. The chips leaving the baking unit
400 are in final form, ready for any desired final inspection and subsequent packaging, as
depicted in step 110.

Application of the present invention to potato slices produces a potato chip
having the texture, consistency, and flavor of deep fat fried potato chips, but without
absorbed fat. The chips resulting from the present invention have an extended shelf life
and the apparatus and method eliminate certain preparation safety hazards associated
with working with large quantities of hot oil.

The present invention can also be applied to other potato products such as potato
strips and the like. Application of the present invention to potato strips produces strips
having the texture, consistency and flavor of deep fat fried strips commonly known as
french fries, but without the quantity of absorbed fat. Frozen strips prepared according to
the present invention and then frozen have an extended shelf life and the apparatus and
method reduce or eliminate certain preparation safety hazards associated with french fry
production.

Specifically, in accordance with a further aspect of the present inventions, potato
strips can be produced using the process and apparatus described above with respect to
preparation of the potatoes and cooks the potato strips in the first and second
impingement ovens, after which the potato strips are frozen and packaged. Because the
potato strips are not dried and moisture is not removed to the same extent as is carried
out for chips, the microwave/hot air dryer 109 can be omitted for potato strips which are
unseasoned and unflavored.

Specifically, the method and apparatus in accordance with the present aspect of
the inventions is illustrated in FIG. 5 where the apparatus, methods and operation are
generally the same up through and including the second impingement oven as were
previously described with respect to those apparatus, methods and operations with
respect to FIG. 1 with the exception of some of the parameters discussed below that may
be different. Generally, raw and unpeeled potatoes are washed and peeled in step 501 in
a suitable apparatus, using an aqueous solution, such as tap water, with a water bath
immersion or a spray system. After washing, the potatoes may be peeled by any conventional peeling means or method, such as by hand or conventional peeling apparatus. The washed and peeled potatoes are then inspected at 502 for any irregularities, where unacceptable potatoes are either discarded or processed in accordance with conventional techniques. For example, unacceptable quality product may be used as animal feed or for other purposes.

The passed potatoes are then sliced by a slicing device at 503 and cut to appropriate size in accordance with the desired final product dimension. The sizes of the potato strips will vary depending on desired choice, while taking into account the puffing and expansion which occurs in the process according to the present inventions. Thereafter, the cooking and other processing will vary as a function of the size of the potato strips produced in the apparatus for slicing and cutting the raw potatoes. The parameters discussed herein, however, will apply to potatoes having the size and water content of potatoes typically accepted for processing into french fries. While the length of the potato strips will vary according to the size of the potatoes, the cross-sectional area of the strips is a dimension that is somewhat more important than the length. In the conventional preparation, the potato strips will have a square cross-sectional shape of about 1/16” up to 1/2” or more depending on the desired thickness of the strip. However, it should be understood that smaller cross-sectional areas are more subject to damage and are more likely to be fragmented or broken during processing. Conversely, thicker strips may not fully or uniformly puff or produce the desired texture or other beneficial “mouth feel” qualities associated with traditional french fry products. Commercially available slicing and cutting devices include the French Fry Slicing apparatus, manufactured by Urschel Laboratories in Valparaiso, Indiana.

After cutting, the potato strips are subjected to tumble washing 504 in conventional apparatus. Alternatively, the potato strips may be washed in other conventional apparatus to remove surface starch and reduce the overall stickiness of the potato strips to assist in separating slices during subsequent steps. The potato strips may be washed with an appropriate spray or with a fluid flow sufficient to remove the desired amount of surface starch.

After the strips are washed in step 504, they are distributed on a belt such as conveyor 208 (FIG. 2) for transport to a high intensity air-knife apparatus where excess
surface moisture is removed using conventional air-knife air jets at 505. The preferred
temperature of the air jets is about 185 to 190°F Fahrenheit, and typical flow rates of
between 50 and 60 cubic feet per minute are believed appropriate for potato strips.

The strips are then distributed onto a continuous conveyor, which may be the
same as conveyor 208 or may be a separate conveyor to accommodate the particular
cooking apparatus and conditions selected by the user. The strips are then transported
through at least one and preferably two individual hot air fluid bed impingement ovens
having the same configuration and operating under the same conditions as those ovens
described above with respect to FIGS. 1 and 2 except may be noted below. The potato
strips are first cooked and dried at 506 at high temperatures and high flow-through rates
in a first two-zone fluid bed impingement oven such as 210 (FIG. 2). First and second
conveyors such as conveyor belts identified as 208 and 211 in FIG. 2 may be used to
move the potato strips through each of the respective impingement ovens, preferably at
different rates of speed as desired by the user. The potato strips are further heated and
cooked at 507 in a second, two-zone fluid impingement oven such as the second oven
212 in FIG. 2. The conveyors may be constructed in the same manner as the conveyors
208 and 211 described above with respect to FIGS. 2 and 3.

Both ovens preferably use the two-zone arrangement described above in
conjunction with FIGS. 2 and 3. For the first impingement oven, the first zone
preferably uses an air temperature of between 450 and 550°F Fahrenheit, and preferably
around 500 -525°F. The second zone of the first oven preferably operates at a temperature
of between 400-550°F Fahrenheit, and preferably around 450-500°F. The potato strips flow
through the first oven at between 4 and 5 feet per minute, depending on the temperature
setting in the oven and the size of the potato strips.

As with the chips described above, the potato strips are rapidly heated in the first
impingement oven causing the strips to expand or "puff." The two zones of the first
impingement oven remove approximately 20-30% of the total moisture, by weight, from
the potato strip, leaving approximately 70-80% of the original moisture, by weight, in the
potato strips.

It should be understood that the temperature settings and flow-through rates for
the first oven, as well as for the second impingement oven described below, when used,
will depend on the size of the potato strips, the desired texture and expansion or puff
created in the strips and the extent of future processing, if any, to be carried out on the potato strips. For example, if the potato strips are to be seasoned, a subsequent drying step may be included, which may affect the temperature, time of cooking and the other parameters set for the impingement ovens.

The second dual zone hot air fluid bed impingement oven, such as that described above with respect to oven 212, cooks the potato strips further at 507, thereby removing additional moisture from the potato strips. The temperatures, flow through rates and other settings and configuration of the second oven are preferably similar to those described above with respect to oven 212. The second oven will operate at a reduced belt speed and at reduced operating temperatures in both of the two zones in the second oven. Preferably, the first zone operates at a temperature of approximately 300-450°F Fahrenheit, preferably within 350 to 400°F, and the second zone operates at approximately 250-400°F Fahrenheit, but preferably in the range of 300-350°F. The conveyor passing through the second oven preferably operates at a speed of approximately 3 to 5 feet per minute, depending upon the temperature of the oven and the size of the potato strips.

The second impingement oven removes approximately 20-30% of the remaining moisture by weight, yielding a moisture range of approximately 60-40% of the original moisture by weight at the output of the second oven. However, higher temperatures and/or slower flow-through rates may be selected in order to further reduce the moisture content of the potato strips, as desired.

It should be understood that the sizes of the ovens, temperature settings and flow-through rates will vary according to the extent of cooking of the strips and according to the sizes of the strips. These parameters will also vary according to the nature and extent of downstream processing of the potato strips. For example, thinner strips will be processed differently, flavored strips which may need to be heated or otherwise processed downstream from the second impingement oven may have a different process, and any desired cooking time after freezing will affect the extent of cooking before freezing.

Fully cooked potato strips from the second impingement oven 507 are input to a freezer for freezing at 508. The cooked potatoes from second oven 507 are input to a freezer 509 (FIG. 6) at an input 510 to be placed on a conveyor 511, preferably formed from stainless steel mesh belts or perforated stainless steel. The freezer includes one or
more blowers 512 for blowing cold air, depicted at 513, through the conveyor 511
carrying the cooked potato strips, depicted at 514 in FIG. 6. Cold air for the blowers 512
is developed by drawing air across an evaporator or other refrigeration device 515. The
potato strips are passed through the freezer 509 at a rate and in a temperature sufficient to
fully freeze the potato strips to the desired temperature. The potato strips are then
transported to an inspection and packaging station for inspection and packaging at 516
(FIG. 5) which would include a conventional conveyor 517 for transporting boxes or
other containers to the output 518 of the freezer 509, for closing, sealing and/or labeling
the containers 519 for shipment. Final inspection can also be carried out at the
inspection station 516.

Generally, the freezer can be a flash freezer, blast freezer, tunnel freezer or other
configuration, known to those in the industry. A suitable freezing unit may be the LSM
series IQF freezer available from Frigoscandia Equipment Company of Bellevue,
Washington. The freezer 509 is suitable for a variety of products and a variety of
capacities and flow-through rates.

The process and apparatus depicted in FIG. 5 is particularly suited for producing
potato strips that are fat free, fully cooked and that simply need to be reheated or
reconstituted for a relatively short time at a serving facility, such as a restaurant or other
location. The frozen strips can be maintained for an extended period frozen without
affecting taste, quality or texture, and they can be reheated in a number of different ways,
suitable to the tastes of the consumer. For example, they can be dipped in hot oil or deep
fried for a relatively few seconds, such as two to five seconds, to heat the strips and to
provide a very light coating simply for taste. Potato strips reconstituted in this way can
be prepared very quickly, and have the same taste, texture, and quality as conventional
french fried potatoes with minimal oil and fat.

The above described process and apparatus for making and freezing fat free
potato strips are believed to be also applicable to french fries having any number of
shapes, to preparation of hash brown potatoes, “cottage fries,” “steak fries,” and other
potato products. The products are fully cooked and have no oil uptake except to the
extent that they may be dipped in hot oil or fat immediately prior to serving.

The potato strips may be dipped or fried in a typical french fryer 520 containing
hot oil or other fluid as desired (see FIG. 7). For potato strips that are fully cooked, the
amount of time the strips are dipped in the oil can be kept to a minimum. As a result, only a thin film of oil is applied to the surfaces of the potato strips to provide flavor and to reheat the potato strips. Conversely, depending on the needs or desires of the consumer, the potato strips can be heated and cooked to a lesser extent in the first and second impingement ovens so that the potato strips can be cooked longer in the fryer 520 if desired. The amount of heating time in the fryer 520 may allow lower temperatures or shorter flow through times through the first and second impingement ovens.

In a further alternative form of the invention (FIG. 8), the potato strips can be provided from the second impingement oven 507 (FIG. 5) to a seasoning and coating apparatus 521 for applying a coating and/or seasoning to the potato strips for flavor or other effects such as texture, quality or taste. The apparatus 521 may be the same or similar to the oil and seasoning apparatus 108 and the tumbler 214 described above with respect to FIGS. 1 and 2, respectively. The coated and/or flavored strips may then be input to a dryer 522, if desired, to fix the coating or seasonings on the strips. The dryer 522 may also provide further moisture removal and/or cooking of the strips, if desired. The dried strips are then passed to a freezer 523 which may be the same as or similar to the freezer 509 described above with respect to FIG. 6.

While the invention has been described in connection with specific embodiments thereof, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptations of the invention following, in general, the principles of the invention, and including such departures from the present disclosure as come within known and customary practice within the art to which the invention pertains.
I CLAIM:

1. A process for making low fat chips from uncooked product slices, comprising the steps of:
   subjecting the raw product slices to a hot air fluid bed impingement oven arrangement; and
   subsequently exposing said slices to a microwave drying process.

2. The process of claim 1, wherein said subjecting step comprises
   transporting said raw product slices through a plurality of hot air fluid bed impingement ovens.

3. The process of claim 2, wherein each hot air fluid bed impingement oven operates under different predetermined conditions.

4. The process of claim 3, wherein said predetermined conditions comprise at least one of:
   temperature; and
   conveyor belt speed.

5. The process of claim 3, wherein each hot air fluid bed impingement oven operates at a different temperature.

6. The process of claim 1 wherein the uncooked product slices are raw potato slices.

7. The process of claim 1, further comprising the step of applying coatings to said slices between said subjecting and exposing steps.

8. The process of claim 7, wherein said coatings applied to said slices comprise oil and seasonings.
9. The process of claim 2, wherein transporting said raw product slices through each hot air fluid bed impingement oven comprises exposing said slices to a two-zone impingement oven arrangement.

10. The process of claim 1 wherein said microwave drying process comprises exposing the product slices to low intensity microwaves.

11. The process of claim 1, further comprising the step of removing surface moisture before said subjecting step.

12. A process for making low fat chips from uncooked product slices, comprising the steps of:

   exposing the slices to a hot air discharging system, thereby causing the slices to expand; and

   drying said slices using microwaves to form a chip.

13. The method of claim 12, wherein said drying step comprises using low intensity microwaves.

14. The method of claim 12, wherein said drying step comprises using microwaves in combination with hot air.

15. The method of claim 12, further comprising the step of removing most of the surface moisture from each raw product slice before exposing the slices to the hot air discharging system.

16. The method of claim 12, wherein said exposing step comprises transporting said slices through a hot air fluid bed impingement oven arrangement.

17. The method of claim 16, wherein transporting said slices comprises conveying said raw product slices through a plurality of hot air fluid bed impingement ovens.
18. The process of claim 17, wherein each hot air fluid bed impingement oven operates under different predetermined conditions.

19. The process of claim 18, wherein said predetermined conditions comprise at least one of:
   temperature; and
   conveyor belt speed.

20. The process of claim 18, wherein each hot air fluid bed impingement oven operates at a different temperature.

21. The process of claim 12 wherein the uncooked product slices are raw potato slices.

22. The process of claim 12, further comprising the step of applying coatings to said slices between said exposing and drying steps.

23. The process of claim 22, wherein said coatings applied to said slices comprise oil and seasonings.

24. The process of claim 16, wherein transporting said raw product slices through each hot air fluid bed impingement oven comprises exposing said slices to a two-zone impingement oven arrangement.

25. The process of claim 15, wherein said surface moisture removal step comprises subjecting the raw product slices to hot air currents.

26. The process of claim 16, wherein each hot air fluid impingement oven operates at a lower temperature than each preceding hot air fluid impingement oven.
27. A product made by the process of first exposing an uncooked product slice to a hot air discharging system, thereby causing the slices to expand and then drying said slices using microwaves, so as to produce a chip without any added fat.

28. The chip of claim 27 wherein the product slice is a potato slice and the resulting chip is an oil free potato chip.

29. A process for making low fat chips from uncooked product slices, comprising the steps of:

- exposing the slices to a heated fluid discharged at high pressure, thereby causing the slice to expand; and
- drying the slices using combination of microwaves and heated fluid.

30. The process of claim 29, wherein said exposing step uses heated air discharged at high pressure.

31. The process of claim 29, wherein said exposing step uses steam discharged at high pressure.

32. The process of claim 29, wherein said drying step comprises using a combination of microwaves and hot air.

33. The method of claim 29, wherein said drying step comprises using low intensity microwaves.

34. The method of claim 29, further comprising the step of removing most of the surface moisture from each raw product slice before said exposing step.

35. The method of claim 29, wherein said exposing step comprises transporting said slices through a hot air fluid bed impingement oven arrangement.
36. The method of claim 35, wherein transporting said slices comprises conveying said raw product slices through a plurality of hot air fluid bed impingement ovens.

37. An apparatus for making low fat chips from uncooked products, comprising:

   a plurality of hot air fluid bed impingement ovens, wherein each oven operates under different predetermined conditions.

38. The apparatus of claim 37, further comprising a combination microwave-hot air drying unit.

39. The apparatus of claim 37, wherein each impingement oven comprises means for transporting slices through the impingement oven.

40. The apparatus of claim 39, wherein said means for transporting slices through each impingement oven comprises a conveyor belt, and wherein each conveyor belt transports slices through each oven at a different speed.

41. The apparatus of claim 37, wherein each oven operates at a different temperature.

42. A process for making low fat food products from uncooked raw food or uncooked food preparations, the process comprising the steps of:

   preparing the uncooked food by forming the uncooked food so that it becomes a raw food item having at least one dimension with a substantially uniform dimension and a moisture content;

   before any heating of the food item, heating the food item using a hot air fluid bed impingement oven to remove at least a portion of the moisture from the food item to produce a food product; and

   packaging the food product.
43. The process of claim 42 wherein the step of preparing includes the step of slicing a potato.

44. The process of claim 42 wherein the step of preparing includes the step of cutting a potato into strips.

45. The process of claim 42 wherein the step of preparing includes the step of forming a food item into a substantially uniform diameter.

46. The process of claim 42 wherein the step of heating is carried out twice, first with a first oven and second with a second oven.

47. The process of claim 42 further comprising the step of drying the food item in a microwave drying oven.

48. The process of claim 47 further comprising the step of applying a seasoning before the step of drying.

49. The process of claim 42 further comprising the steps of washing the raw food and slicing the raw food to prepare the food item to have a uniform dimension in the form of a uniform thickness, and the step of heating the food item in a second hot air fluid bed impingement oven after heating in the first hot air fluid bed impingement oven.

50. The process of claim 49 further comprising the step of freezing the food items after heating in the second oven.

51. The process of claim 49 further comprising the step of heating the food items in a microwave dryer after the heating in the second oven and packaging the food items in packages.

52. The process of claim 51 further comprising the step of applying a seasoning to the food items before the step of heating with a dryer.
53. An apparatus for making low fat food products from uncooked raw food or uncooked food preparations, the apparatus comprising:

means for preparing the uncooked food by forming the uncooked food so that it becomes a raw food item having at least one dimension with a substantially uniform dimension and a moisture content;

a hot air fluid bed impingement oven coupled to the preparing means for receiving unheated raw food items from the preparing means to remove at least a portion of the moisture from the food item to produce a food product; and packaging means for packaging the food product.

54. The apparatus of claim 53 further comprising a second impingement oven for further heating the food items to remove moisture from the food items.

55. The apparatus of claim 54 further comprising a microwave dryer between the second oven and the packaging means for further drying the food items.

56. The apparatus of claim 53 further comprising a freezer coupled between the oven and the packaging means for receiving food items that have been passed from the oven and that will be passed from the freezer to the packaging means.
FIG. 1

- **WASH & PEEL** → **INSPECT** → **SLICE** → **TUMBLE WASH**

- **HIGH INTENSITY AIR KNIFE** → **FIRST TWO-ZONE FLUID BED IMPINGEMENT OVEN** → **SECOND TWO-ZONE FLUID BED IMPINGEMENT OVEN**

- **OIL & SEASON** → **MICROWAVE/HOT AIR DRYER** → **PACKAGING**
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) : A21D 6/00
US CL : 426/242
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 426/102, 242, 243, 296, 464, 510, 523, 524, 560, 637, 808; 99/447, 451; 126/21/A; 219/400

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5,393,543 A (LAUFER) 28 February 1995, see entire document.</td>
<td>1, 4, 6, 7, 10, 12-14, 21, 22, 29, and 33</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,470,600 A (PETELLE et al) 28 November 1995, see entire document.</td>
<td>1-56</td>
</tr>
<tr>
<td>Y</td>
<td>US 4,906,483 A (KLOOS) 06 March 1990, see column 3, lines 58-61.</td>
<td>56</td>
</tr>
</tbody>
</table>

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

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

Date of the actual completion of the international search: 20 JANUARY 1998

Date of mailing of the international search report: 03 FEB 1998

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