

OIL ENROBED PAR-FRIED POTATO STRIPS

BACKGROUND OF THE INVENTION

The present invention relates to oil enrobed, and in particular frozen oil enrobed par-fried potato strips which when oven finished have a crisp surface layer and a moist inner core. The finished fry has substantially the same taste, quality and characteristics as French fried potatoes that have been deep fried in fat.

French fries are one of the most popular convenience foods. French fried potato strips, commonly referred to as French fries, served in most fast food restaurants are purchased in bulk from commercial suppliers in the form of partially fried (par-fried) and frozen potato strips which are stored in a frozen condition until shortly before serving. At that point the par-fried potato strips are prepared for consumption by frying in fat or oil. In addition, frozen par-fried potato strips are also purchased by the consumer for pan frying, deep frying or oven finishing.

The use of frozen par-fried potato strips instead of fresh potato strips has been widely adopted in fast food restaurants because of the convenience and savings in labor costs they provide. Frozen par-fried potato strips also provide convenience for the consumers who purchase them for home use. Few people want to go through the preparation steps required to produce French fries from fresh potatoes.

Most restaurants, including the large franchise chains, prepare their French fried potatoes from the frozen or chilled par-fried product, typically finishing them by deep-frying. Although par-fried potato strips which can be oven finished are presently available, they suffer from a disadvantage in that when they are baked, they produce limp, soggy fries which do not resemble deep fried potatoes in texture or flavor.

The two most important textural attributes in French fried potatoes which have been deep fried are interior moistness and crust crispness. The external surfaces of good textured French fries are moderately crisp and are not excessively oily. The interior portions are also well cooked, tender, mealy and free from sogginess.

Suppliers of frozen par-fried potato strips have proposed a number of solutions to improve the crispness of oven finished French fries. Most of the methods for producing "finished baked fries" require coating the par-fried potato strip with firming agents such as modified starches, gums, alginates, calcium salts, and the like. See for example U.S. 5,000,970 (Shanbhag et al.) and U.S. 5,302,410 (Calder et al.). Another method requires surface coating the par-fry with oil or fat, for example, U.S. 3,265,964 issued to Kellermeier. The results obtained by such surface treatment procedures, have had only a limited degree of success.

The major problem with oven finished fries is that the texture of a high quality deep fried French fry has never been duplicated. In particular, the same internal moist texture surrounded by a crisp yet

tender outer surface or "crust" has not been achieved on a commercial scale. Although oil or fat coatings have been applied to par-fries in the past, the oven-finished French fries produced therefrom are generally limp and soggy or are dry and tough. This may be due to any number of reasons; for example, the bulk moisture and fat of the par-fry may not have been optimized for delivering a desirable texture upon oven finishing, the desirable moist interior may have been lost in the course of the processing steps, or the crust area may have become soggy due to the inability of water to escape during cooking.

It has been surprisingly discovered that oil/fat coated par-fries wherein the bulk moisture, interior moisture and fat level are controlled, produce French fries having substantially optimized taste, color and textural characteristics when oven finished.

As has been stated, the production of oil coated French fries is known in the art. However, the present invention offers significant improvements in the texture of the oven finished fry.

The present invention enables the production of French fries in an oven which have deep fried taste and textural properties. One aspect of the present invention is based in part on the surprising discovery that the pre-enrobed par-fried potato strips must have a certain bulk moisture level. Another aspect of the present invention is based on the fact that the par-fried potato strips are coated on the surface with a specific levels of fat or oil.

Accordingly, it is an object of the present invention to provide par-fried potato strips, enrobed with a surface coating of fat or oil, which when oven finished, closely resemble the texture and flavor of deep fried fast food French fries.

It is another object of the present invention to provide a product which is prepared in an oven and which provides a highly palatable French fried product, which has a crisp surface texture and a tender moist interior.

It is still another object of the present invention to provide frozen par-fried potato strips which can be finished in an oven of fast food restaurants or in the consumer's home which is virtually indistinguishable from deep fried French fried potatoes.

SUMMARY OF THE INVENTION

The present invention relates to oil enrobed par-fried potato strips suitable for oven finishing comprising:

- (a) par-fried potato strips having from about 34% to about 58% bulk moisture; and
- (b) from about 8% to about 30% total fat;

said par-fried potato strips have a substantially uniform surface coating of oil or fat wherein the surface coating comprises from about 2% to about 15% by weight of said par-fried potato strips.

The potato strips when oven finished have a color, texture, mouthfeel and taste which is virtually indistinguishable from commercially prepared French fries that have been prepared by deep fat frying such as McDonaldsTM French fries.

DETAILED DESCRIPTION

The present invention relates to oil enrobed par-fried potato strips, and in particular, frozen oil enrobed par-fried potato strips suitable for oven finishing prior to consumption. Although the invention is applicable to a number of finished heating processes, it has particular application to toasters, toaster ovens, forced air ovens, convection ovens, high air velocity ovens, hot air impingement ovens, infrared ovens, combined convection/infrared ovens, combined microwave/convection ovens and conventional home ovens. Potato strips of the present invention, when oven finished have the flavor and texture of deep fried French fries.

As used herein the terms "par-fry" or "par-fried" refer to potato strips that have been subjected to at least one frying process (e.g. deep-frying) but which have not been completely cooked.

As used herein the term "oven finishing" refers to converting the product to a ready-to-eat form by cooking in a toaster, toaster oven, forced air oven, convection oven, high air velocity oven, hot air impingement oven, infrared oven, combined convection/infrared oven, combined microwave/convection oven or a conventional home oven.

As used herein the term "oven finished" refers to a product that has been subjected to an oven baking process to convert it to a ready-to-eat form. Obviously, the advantages of the invention cannot be realized until the oil enrobed par-fry is cooked, as by baking in an oven such as a forced air convection oven, a combined infrared radiation/forced air convection oven or a conventional home oven. It is not meant to imply that the final cooking step necessarily forms any part of the invention, which is concerned primarily with the attributes of the par-fry.

As used herein the term "fat" or "edible oil" refers to edible fatty substances in a general sense, including natural or synthetic fats and oils consisting essentially of triglycerides, such as, for example soybean oil, corn oil, cottonseed oil, sunflower oil, palm oil, coconut oil, canola oil, fish oil, lard and tallow, which may have been partially or completely hydrogenated or modified otherwise, as well as non-toxic fatty materials having properties similar to triglycerides, herein referred to as fat substitutes, which materials may be partially or fully indigestible. The terms "fat" and "oil" are used interchangeably. Reduced calorie fats and edible non-digestible fats, oils or fat substitutes are also included in the term.

As used herein the term "enrobed" refers to a substantially uniform coating on the surface of the par-fry. The coating may also be discontinuous (i.e. globules or droplets).

As used herein the term "conditioned oil" refers to oil which has been previously used for frying for such a time that it has developed fried flavor.

Unless otherwise stated, all percentages, ratios or proportions expressed herein are by weight.

Pre-Enrobed Potato Strips

The pre-enrobed par-fried potato strips may be prepared according to the processing steps that are conventional to most par-fry production techniques. The pre-enrobed potato strips may either be prepared from raw potatoes or from potato strips which have previously been par-fried or par-fried and frozen. Raw potatoes of a variety known to be suitable for preparing French fries (e.g., Russet Burbank variety), are washed, peeled and trimmed in accordance with conventional practice and are cut into strips of a desired size and shape customarily used for French fries such as shoestring potato strips, crinkle-cut strips, and straight cut thick strips. After cutting, the strips may be washed to remove surface starch.

In the practice of the present invention it is preferred that the potato strips known in the art as "shoestrings" be used. Shoestring potato strips, as used herein refer to potato strips that are from about 3/16 to about 5/16 inch square in cross-section and from about 2.5 inches to about 5 inches in length.

Other potato strips which may be used herein are known in the art as "crinkle cut" strips. Such strips usually average from about 5/16 to about 1/2 inch in cross-section and from about 2 to about 4 inches in length.

Also, straight-cut thick potato strips (also called regular-cut) of from about 5/16 to about 1/2 inch square in cross-section and about 2.5 to about 5 inches in length may be used. Larger potato strips of the type referred to as "steak fries" may also be used. Typically, these potato strips have a rectangular cross-section of about 1/2 inch by about 7/8 inch.

The potato strips are blanched according to conventional procedures known in the art. This is done to inactivate enzymes and remove excess free sugars from the surfaces of the cut strips. Typically the strips are blanched by immersion in hot water at a temperature of about 140°F (60°C) to about 200°F (93.3°C) for about 3 to about 20 minutes depending upon strip size. Alternatively, the strips may be blanched in steam, at atmospheric pressure for about 2 to about 10 minutes.

Following the blanching step, the potato strips may be treated according to conventional methods known in the art. For instance, the potato strips may be subjected to additional water immersion steps to further leach excess sugars or the strips may be treated with sodium acid pyrophosphate (SAPP), a chelating agent used to prevent discoloration of the strips. Dextrose (corn sugar) may also be applied to the surface of the strips in order to yield a desired level of brown color development during subsequent processing. Other treatments known in the art may also be used.

After blanching and the optional treatments described above, the potato strips are drained and optionally dehydrated to reduce their moisture content. During dehydration of the strips the moisture content is typically reduced to a point at which the strips have lost from about 10% to about 30% of their initial weight, preferably about 15% to about 20% of their initial weight. Any of the conventional drying procedures used in the production of par-fried potato strips may be used, such as, for example, subjecting

the potato strips to heated air at temperatures of from about 150°F (65.6°C) to about 350°F (176.7°C) for from about 5 to about 20 minutes. Microwave or radio-frequency drying may also be used.

The blanched potato strips are then immersed in an edible oil for a time sufficient to produce par-fried potato strips having from about 38% to about 58% bulk moisture. Typically, the shoestring-cut potato strips have from about 40% to about 56% bulk moisture. Preferably the potato strips have from about 42% to about 54%, more preferably from about 44% to about 50% moisture. These par-fried potato strips have from about 6% to about 25%, preferably from about 8% to about 22%, more preferably from about 10% to about 20% and most preferably from about 12% to about 18% total fat. This can be achieved by immersing the potato strips in oil, for example, at a temperature of from about 270°F (132°C) to about 385°F (196°C). Of course the immersion time will be dependent on the specific oil temperature, dimensions of the potato strips, the batch size, the volume of the frying kettle and the initial moisture content of the potato strips. This can be determined by one skilled in the art. Other techniques such as a heated oil spray which surrounds the potato strip with hot oil or frying using an oil foam can also be used.

Thicker-cut potato strips (e.g., straight, regular-cut, crinkle-cuts and steak fries) maybe fried to slightly higher bulk moisture contents. For example, regular and crinkle-cut par-fries (5/16" to 1/2" cross section) may be fried to about 40% to about 60% bulk moisture content; and steak fry par-fries (1/2" by 7/8" cross-section) may be fried to about 42% to about 62% moisture.

In a preferred embodiment of the present invention the potato strips which are to be enrobed have been previously par-fried and frozen. The pre-enrobed par-fried strips are commercially prepared and may have been subjected to multiple processing steps (i.e., par-fry and freezing, multiple par-fryings and freezing). The only limitations are that the pre-enrobed par-fried potato strips meet the requisite bulk moisture and fat level.

After par-frying the par-fried potato strips may be immediately enrobed with oil, or they may be cooled or frozen prior to enrobing. Chilling or freezing of the par-fries may be accomplished by methods known in the art. For example, the par-fried potato strips may be subjected to a blast of cold air at a temperature of less than about -20°F, or the strips may be immersed in a liquid refrigerant, such as liquid nitrogen. Conventional freezing processes can be used. It is preferred that the par-fried potato strips be frozen quickly, i.e., in less than 20 minutes, preferably less than 5 minutes after completion of the par-frying.

Surface Coating/Enrobing

In order to ensure that an outer crust similar to that of a deep fried French fry will be produced in an oven, it is necessary to coat the surface of the par-fried potato strips with an edible fat. The surface coating may be applied immediately after removal of the par-fried potatoes from the fryer or the coating can be applied to frozen, chilled, or room temperature par-fried potato strips.

The fat compositions used to coat or enrobe the par-fried potato strips can be applied to the surface of the potato strips by a variety of means including immersion, dipping, spraying, blowing, pouring, pan coating (e.g., in a revolving pan), tumble coating, rolling around in a container of a fat composition, falling film methods, enrobing and curtain coating. Preferably the edible liquefied fat is applied in a substantially uniform coating by spraying the liquid fat onto the surface of the par-fried potato strips or by dipping the par-fried potato strips into the liquid fat. The coating may be continuous or discontinuous so long as it is uniformly distributed.

To achieve oil levels on the surface of the potato strips, in the range of from about 2% to about 15% by weight of the par-fried potato strips, the following oil spray technique can be used. The oil is maintained at a temperature of from about 70°F (21°C) to about 200°F (93°C), preferably from about 100°F (37.8°C) to about 180°F (82.2°C) and more preferably from about 120°F (48.9°C) to about 160°F (71.1°C). The spray nozzles are arranged to administer the oil evenly whether the oil is atomized during the spraying or simply sprayed in fine droplets, preferably over the potato strips in a single layer. The rate of application of the oil, determined by the volume of oil that is sprayed and the amount of par-fried potato strips that are sprayed, is preferably such that the weight of the par-fried potato strips is increased by about 2% to about 15% after spraying.

A surface oil coating can also be applied via an immersion or dipping technique. For example, the par-fried potato strips are frozen and equilibrated at 0°F (-17.8°C). The frozen par-fried strips are immersed rapidly (e.g. 1-3 seconds) into oil at a temperature of about 335°F (168.3°C) and then immediately re-frozen by immersion in liquid nitrogen. This type of enrobing process adds a coating of oil onto the surface of the par-fried potato strips sufficient to increase the weight of the strips by about 2% to about 15%.

It is important to maintain the fat in a substantially liquid state to allow the application of a sufficient and uniform coating. The application of the fat or oil before oven finishing is critical to providing a product with the texture of a conventional deep fried French fry.

Edible Oils

A variety of edible fats and oils may be used to coat the surface and to fry the par-fried potato strips. Edible fats and oils suitable for use include but are not limited to beef tallow, lard, cottonseed oil, canola, soybean oil, corn oil, palm oil, fish oil, safflower oil, sunflower oil, coconut oil, peanut oil, medium chain triglycerides, structured triglycerides containing a combination of short or medium chain fatty acids and long chain fatty acids (e.g. Caprenin-like) and the like or combinations thereof. If desired the oils may be conditioned or flavored, see Flavored Vegetable Oils as a Substitute for Beef Tallow in Deep Frying Applications, Food Technology, pp 90-94 (1989) and U.S. Patent 5,104,678 (Yang et al.)

Preferably the edible fat or oil used to fry and enrobe the par-fried potato strips has a free fatty acid level of about 0.8% or less.

The edible oils used for frying or enrobing the par-fried potato strips include natural or synthetic fats and oils. The oils may be partially or completely hydrogenated or modified otherwise. Additionally non-toxic, fatty materials having properties similar to triglycerides such as sucrose polyesters and OleanTM, from the Procter and Gamble Company, and reduced calorie fats, polyol fatty acid polyesters, and diversely esterified polyol polyesters or combinations of regular fats and fat substitutes may also be used herein.

One reduced calorie fat that has been found to be useful comprises a fairly high level (e.g., at least about 85%) of combined MML and MLM triglycerides, where M is typically a mixture of C₈-C₁₀ saturated fatty acids and L is predominantly behenic acid, but can be C₂₀-C₂₄. See U.S. Patent 4,888,196 to Ehrman et al., issued December 9, 1989 and U.S. Patent 5,288,512 issued to Seiden, February 22, 1994 for the synthesis and more detailed description of these reduced calorie fats.

The MML, LLM, triglycerides are further characterized by having a fatty acid composition which comprises from about 35% to about 60% combined C₈-C₁₀ saturated fatty acids, a ratio of C₈-C₁₀ saturated fatty acids of from about 1:5 to about 25:1, and from about 35% to about 60% behenic fatty acid.

By "reduced calorie " as used herein is meant fats that provide an at least about 10%, and preferably an at least about 30%, reduction in calories relative to corn oil. The reduction in calories provided by these reduced calorie fats can be determined by studies similar to that described by Peters, J.C. et al., Journal of the American College of Toxicology, Vol. 10, No. 3, 1991, pp. 357-367.

By "polyol" is meant a polyhydric alcohol containing at least 4, preferably from 4 to 11 hydroxyl groups. Polyols include sugars (i.e., monosaccharides, disaccharides, and trisaccharides), sugar alcohols, other sugar derivatives (i.e., alkyl glucosides), polyglycerols such as diglycerol and triglycerol, pentaerythritol and polyvinyl alcohols. Specific examples of suitable sugars, sugar alcohols and sugar derivatives include xylose, arabinose, ribose, xylitol, erythritol, glucose, methyl glucoside, mannose, galactose, fructose, sorbitol, maltose, lactose, sucrose, raffinose, and maltotriose.

By "polyol fatty acid polyester" is meant a polyol having at least 4 fatty acid ester groups. Polyol fatty acid esters that contain 3 or less fatty acid ester groups are generally digested in, and the products of digestion are absorbed from, the intestinal tract much in the manner of ordinary triglyceride fats or oils, whereas those polyol fatty acid esters containing 4 or more fatty acid ester groups are substantially non-digestible and consequently non-absorbable by the human body. It is not necessary that all of the hydroxyl groups of the polyol be esterified, but it is preferable that disaccharide molecules contain no more than 3 unesterified hydroxyl groups for the purpose of being non-digestible. Typically, substantially all, e.g., at least about 85%, of the hydroxyl groups of the polyol are esterified. In the case of sucrose polyesters, typically from about 7 to 8 of the hydroxyl groups of the polyol are esterified.

The polyol fatty acid esters typically contain fatty acid radicals typically having at least 4 carbon atoms and up to 26 carbon atoms. These fatty acid radicals can be derived from naturally occurring or

synthetic fatty acids. The fatty acid radicals can be saturated or unsaturated, including positional or geometric isomers, e.g., cis- or trans- isomers, and can be the same for all ester groups, or can be mixtures of different fatty acids.

Liquid non-digestible oils have a complete melting point below about 37°C include liquid polyol fatty acid polyesters (see Jandacek; U.S. Patent 4,005,195; Issued January 25, 1977); liquid esters of tricarballic acids (see Hamm; U.S. Patent 4,508,746; Issued April 2, 1985); liquid diesters of dicarboxylic acids such as derivatives of malonic and succinic acid (see Fulcher; U.S. Patent 4,582,927; Issued April 15, 1986); liquid triglycerides of alpha-branched chain carboxylic acids (see Whyte; U.S. Patent 3,579,548; Issued May 18, 1971); liquid ethers and ether esters containing the neopentyl moiety (see Minich; U.S. Patent 2,962,419; Issued Nov. 29, 1960); liquid fatty polyethers of polyglycerol (See Hunter et al; U.S. Patent 3,932,532; Issued Jan. 13, 1976); liquid alkyl glycoside fatty acid polyesters (see Meyer et al; U.S. Patent 4,840,815; Issued June 20, 1989); liquid polyesters of two ether linked hydroxypolycarboxylic acids (e.g., citric or isocitric acid) (see Huhn et al; U.S. Patent 4,888,195; Issued December 19, 1988); liquid esters of epoxide-extended polyols (see White et al; U.S. Patent 4,861,613; Issued August 29, 1989); all of which are incorporated herein by reference, as well as liquid polydimethyl siloxanes (e.g., Fluid Silicones available from Dow Corning).

The polyol fatty acid polyesters that are liquid have minimal or no solids at a temperature of 98.6 °F (37°C), i.e., body temperatures. These liquid polyol polyesters typically contain fatty acid ester groups having a high proportion of C₁₂ or lower fatty acid groups or else a high proportion of C₁₈ or higher unsaturated fatty acid groups. In the case of those liquid polyol polyesters having high proportions of unsaturated C₁₈ or higher fatty acid groups, at least about half of the fatty acids incorporated into the polyester molecule are typically unsaturated.

The liquid polyol fatty acid polyesters can be prepared by a variety of methods known to those skilled in the art. These methods include: transesterification of the polyol (i.e. sugar or sugar alcohol) with methyl, ethyl or glycerol fatty acid esters using a variety of catalysts; acylation of the polyol with a fatty acid chloride; acylation of the polyol with a fatty acid anhydride; and acylation of the polyol with a fatty acid, per se. See, for example, U.S. Patent Nos. 2,831,854, 3,600,186, 3,963,699, 4,517,360 and 4,518,772, all of which are incorporated by reference, which disclose suitable methods for preparing polyol fatty acid polyesters. Specific, but non-limiting, examples of the preparation of liquid polyol polyesters suitable for use in the practice of the present invention are disclosed in Young et al; World Patent Application US91-02394 (publication number WO91-15964); published October 31, 1991, which is incorporated by reference. The liquid polyol polyesters can contain behenic acid.

Polyol fatty acid polyesters that are solid at temperatures of about 37°C and higher have the ability to bind high levels of edible liquid non-digestible oils, such as liquid polyol polyesters previously described, when included in appropriate amounts. This capacity to bind liquid non-digestible oils enables

these solid polyol polyesters to control or prevent the passive oil loss problem associated with the ingestion of such liquid oils.

Diversely Esterified Polyol Polyesters

One preferred class of suitable solid polyol polyesters for use in the liquid/solid blend are those wherein the esters groups comprise a combination of (a) C₁₂ or higher unsaturated fatty acid radicals, C₄-C₁₂ fatty acid radicals or mixtures thereof, and (b) at least about 15% C₂₀ or higher saturated fatty acid radicals, preferably at least about 30%, more preferably at least about 50%, most preferably at least about 80%, long chain saturated fatty acid radicals.

Suitable unsaturated fatty acid radicals contain at least 12, preferably from 12 to 26, more preferably from 18 to 22, most preferably 18, carbon atoms. Suitable short chain saturated fatty acid radicals contain from 4 to 12, preferably from 6 to 12, and most preferably from 8 to 12, carbon atoms. Suitable long chain saturated fatty acid radicals contain at least 20, preferably from 20 to 26, most preferably 22, carbon atoms. The long chain unsaturated fatty acid radicals can be used singly or in mixtures with each other, in all proportions, as is also the case with the short chain and long chain saturated fatty acid radicals. In addition, straight chain (i.e. normal) fatty acid radicals are typical for the short chain and long chain saturated fatty acid radicals, as well as the long chain unsaturated fatty acid radicals. Examples of suitable long chain unsaturated fatty acid radicals for use in these solid polyol polyesters are monounsaturated radicals such as lauroleate, myristoleate, palmitoleate, oleate, elaidate, and erucate, and polyunsaturated radicals such as linoleate, arachidonate, linoleate, eicosapentaenoate, and docosahexaenoate. In terms of oxidative stability, the monounsaturated and diunsaturated fatty acid radicals are preferred. Examples of suitable short chain saturated fatty acid radicals are acetate, butyrate, hexanoate (caproate), octanoate (caprylate), decanoate (caprate), and dodecanoate (laurate). Examples of suitable long chain saturated fatty acid radicals are eicosanoate (arachidate), docosanoate (behenate), tetracosanoate (lignocerate), and hexacosanoate (cerotate).

Mixed fatty acid radicals from oils which contain substantial amounts of the desired long chain unsaturated fatty acids, short chain saturated fatty acids, or long chain saturated fatty acids can be used as sources of fatty acid radicals in preparing the solid polyol polyesters useful in the liquid/solid blend type of non-digestible fat component. The mixed fatty acids from such oils should preferably contain at least about 30% (more preferably at least about 50%, most preferably at least about 80%) of the desired long chain unsaturated, short chain saturated or long chain saturated fatty acids. For example, palm kernel oil fatty acids can be used instead of a mixture of the respective pure saturated fatty acids having from 8 to 12 carbon atoms. Similarly, rapeseed oil fatty acids or soybean oil fatty acids can be used instead of a mixture of the respective pure monounsaturated and polyunsaturated fatty acids having 12 to 26 carbon atoms, and hardened (i.e., hydrogenated) high erucic rapeseed oil fatty acids can be used in place of a mixture of the respective pure long chain saturated fatty acids having from 20 to 26 carbon atoms.

Preferably, the C₂₀ or higher saturated fatty acids (or their derivatives, e.g. methyl esters) are concentrated, for example, by distillation. An example of source oils for these solid polyol polyesters are high oleic sunflower oil and substantially completely hydrogenated high erucic rapeseed oil. When sucrose is substantially completely esterified with a 1:3 by weight blend of the methyl esters of these two oils, the resulting polyester has a molar ratio of unsaturated C₁₈ acid radicals to saturated C₂₀ or higher acid radicals of about 1:1, the saturated C₂₀ and C₂₂ acid radicals being about 28.6% of the total fatty acid radicals. The higher the proportion of the desired long chain unsaturated/short chain saturated and long chain saturated fatty acids in the source oils used in making the solid polyol polyesters, the more efficient the polyesters will be in their ability to bind the liquid non-digestible oils.

The molar ratio of (a) long chain unsaturated fatty acid radicals or short chain fatty acid radicals or mixtures thereof, to (b) long chain saturated fatty acid radicals, is from about 1:15 to about 1:1. Preferably, this molar ratio of (a) to (b) radicals is from about 1:7 to about 4:4, most preferably from about 1:7 to about 3:5.

Examples of solid polyol fatty acid polyesters containing mixtures of (a) and (b) radicals include sucrose tetrabehenate tetracaprylate, sucrose pentabehenate trilaurate, sucrose hexabehenate dicaprylate, sucrose hexabehenate dilaurate, the sorbitol hexaester of palmitoleic and arachidic fatty acid radicals in a 1:2 molar ratio, the raffinose octaester of linoleic and behenic fatty acid radicals in a 1:3 molar ratio, the maltose heptaester of a mixture of sunflower oil and lignoceric fatty acid radicals in a 3:4 molar ratio, the sucrose octaester of oleic and behenic fatty acid radicals in a 2:6 molar ratio, the sucrose octaester of lauric, linoleic and behenic fatty acid radicals in a 1:3:4 molar ratio, and the sucrose hepta- and octaesters of C₁₈ mono- and/or di-unsaturated fatty acid radicals and behenic fatty acid radicals in a molar ratio of unsaturated:behenic acid radicals of about 1:7 to 3:5.

Enrobing parameters

The edible oil is applied to the surface of the par-fried potato strips in an amount sufficient to prevent rapid migration of moisture from the interior during oven finishing. Typically an amount of from about 2% to about 15% by weight of the par-fried potato strips, preferably from about 3% to about 12%, and more preferably an amount of from about 4% to about 10% oil is used to coat the surface of the par-fried potato strips.

The oil enrobed par-fried potato strips before baking (shoestring-cut), typically comprise from about 34% to about 54% bulk moisture. Preferably, the shoestring-cut, oil enrobed par-fried potato strips comprise from about 36% to about 52%, more preferably from about 38% to about 50%, and even more preferably from about 40% to about 48% bulk moisture. Additionally, the oil enrobed par-fries before baking comprise from about 8% to about 30% total fat, wherein the level of surface fat is from about 2% to about 15% by weight of the par-fried potato strips. Preferably, the oil enrobed par-fries before baking

comprise from about 10% to about 28%, more preferably from about 12% to about 26%, and even more preferably from about 16% to about 24% total fat.

Thicker-cut oil enrobed par-fried potato strips may have slightly higher bulk moisture contents. For example, regular and crinkle-cut oil enrobed par-fries (5/16" to 1/2" cross-section) may comprise about 36% to about 56% bulk moisture; and steak fry oil enrobed par-fries (1/2" by 7/8" cross section) may comprise about 38% to about 58% bulk moisture.

After coating the surface of the par-fries, the oil enrobed par-fried potato strips may be frozen, packaged and stored or shipped for subsequent use. Typical frozen storage temperatures ranges from about -20°F (-28.9°C) to about 10°F (-12.2°C). Freezing the oil enrobed par-fried potato strips may be accomplished by methods known in the art. The strips may be contacted with a liquid refrigerant which is at a temperature below 0°F (-17.8°C), preferably below -20°F (-28.9°C). One may also use any of the fluorocarbons which exist in the liquid state. Particularly preferred is the use of liquid nitrogen.

The step of contacting the refrigerant with the oil enrobed par-fried potato strips may be accomplished by dipping the strips in a pool of the refrigerant, or by spraying the refrigerant on them. In any case, the time of contact is limited so that preferably only the surface layers of the strips become frozen. The time required to achieve the desired degree of freezing will vary depending on such factors as the temperature of the refrigerant, the size of the potato strips, etc. The freezing may either be a surface freeze or a total freeze. It is not essential that the surface freeze be accomplished by the use of a liquid refrigerant; one may use a refrigerant in a gaseous state. For example, the oil enrobed par-fried potato strips may be subjected to a current of cold air at a temperature below 0°F (-17.8°C). A convenient method is to use a conventional blast freezer or a high velocity current of air where the potato strips are subjected to a blast of cold air at a temperature of less than or equal to about -20°F (-28.9°C). Alternatively, the potato strips may be placed in a freezer compartment, for example, at -10°F (-23.3°C), of a suitable size such as a commercial or industrial unit.

However, the freezing step may be excluded and the enrobed par-fry potato strips may be immediately oven finished without freezing.

Oven Finishing

The time period and temperature for preparing the oven finished French fries will vary depending upon the quantity of strips, their initial temperature, the type of oven and the oven conditions (e.g., temperature, air velocity) used, and the thermal properties of the oil-enrobed par fries. Of particular importance are the thermal conductivity of the low-moisture crust region, the thermal conductivity of the high-moisture interior starch-matrix core and the surface heat transfer coefficient of the par fry. In general, higher thermal conductivities and higher surface heat transfer coefficients will result in more rapid transfer of heat from the oven to the fry, resulting in reduced cooking time. Since it is an object of the present invention to provide a fast food process for quickly finishing frozen par-fries in an oven, these

properties are of particular importance. The desirable thermal conductivities at oven temperature of the low moisture crust region in the oil-enrobed par fry are from about 0.1 to about 0.3 watts/m-°C. The desirable thermal conductivities at oven temperature of the high moisture core region in the oil-enrobed par fry are from about 0.4 to about 0.7 watts/m-°C. The thermal conductivity of the crust region can be adjusted to the desirable range by controlling the level of moisture and fat in the crust.

The surface heat transfer coefficient of the oil-enrobed par fry is a function of forced air velocity, air temperature, and the nature of the oil film at the surface of the par fry. Higher surface heat transfer coefficients are desirable since this will generally lead to faster cooking time, and the formation of more distinct and crisp low moisture crust region in the oven-finished French fry. The desirable surface heat transfer coefficients at oven temperature of the oil-enrobed par fry in the oven are from about 50 to about 400 watts/m²-°C. The surface heat transfer coefficient is increased as a consequence of enrobing the par fry with an edible fat or oil, which increases the conduction of heat from the surrounding air to the fry surface. The surface of the fry may also be modified to improve the absorption of radiant heat from the oven. A typical method of accomplishing this would be to alter the color, porosity, and or reflectivity of the surface. Increasing the velocity of the oven air at the surface of the par fry will also increase the surface heat transfer coefficient. The oven air velocity should be high enough to achieve a satisfactory heat transfer coefficient, but not so high as to strip away the enrobing oil on the surface.

The oven finished French fries are a golden brown color and have a crisp crust and a moist interior. The finished French fries have a color, texture, mouthfeel and taste which closely resembles commercially prepared French fried potatoes that have been prepared by deep fat frying, such as McDonaldsTM.

Additional Ingredients

Flavoring agents, such as salt, pepper, butter, onion, or garlic may be added to the oil to enhance the flavor or modify the flavor to any desired taste. One skilled in the art will readily appreciate that the aforementioned listing of flavoring agents is in no way exhaustive, but is merely suggestive of the wide range of additives which are suitable for use in the practice of the present invention.

Other ingredients known in the art may also be added to the edible fats and oils used to fry and enrobe the par-fried potato strips, including antioxidants such as TBHQ, chelating agents such as citric acid, and antifoaming agents such as dimethylpolysiloxane.

A primary advantage of the present invention is that it provides par-fried potato strips which, upon oven finishing, yield French fries of excellent texture and taste.

Another advantage of the invention is that the French fry potato producer is now able to produce oven-finished French fries having excellent texture. Often, in commercial operations the par-fried potato strips are deep-fried to obtain a desirable texture. As a result of this invention, the final frying step is completely unnecessary because the crisp crust and moist interior of the oven finished fries are virtually

indistinguishable from French fries which have been finished using a deep frying process. Besides being advantageous from a texture standpoint, the invention also offers an economical advantage to the producer. It should be emphasized that the amount spent for cooking oil is one of the major expenditures incurred by the producer of French fries.

While specific preferred processing steps have been disclosed to facilitate an understanding of the invention, the functional equivalents can be substituted or additional ingredients may be added without departing from the spirit or essential characteristics of the present invention.

ANALYTICAL PROCEDURES

The methods for determining the bulk moisture and total fat of par-fried potato strips and oil enrobed par-fried potato strips are set forth below:

Determination of Bulk Moisture Content

Moisture content is determined by a forced air oven method as follows:

1. Uniformly grind up a representative sample of potato strips in a blender or conventional food processor.
2. Accurately weigh approximately 5 grams of ground sample (weight "A") into a previously tarred metal pan or dish.
3. Place the metal dish containing the sample in a forced air convection oven at 105°C for 2 hours.
4. After 2 hours, remove the metal dish containing the dried sample and allow to cool to room temperature in a desiccator over a desiccant such as anhydrous calcium sulfate.
5. Re-weigh the dish containing the dried sample and calculate the weight of the dried sample (weight "B") by subtracting the dish tare weight.
6. Calculate the percent moisture of the sample as follows:

$$\% \text{ Moisture} = [(A - B) / (A)] \times 100$$

Determination of Total Fat Content

Total fat content is determined by a solvent extraction method as follows:

Apparatus

1. Soxtec HT6 extraction system; unit includes heating block and cooling condenser.
2. Recirculating water bath for cooling condenser.
3. Recirculating oil bath for heating block.
4. Extraction beakers.
5. Extraction thimbles, 26 mm (Fisher TC1522-0018)

6. Nitrogen purging gas
7. Vacuum drying oven
8. Analytical balance (4 place)
9. Dispensing pipette (50 ml)

Materials

1. Methylene chloride (Baker 9315-33)
2. Boiling stones (Chemware PTFE Fisher 09-191-20)
3. Silicone oil (Fisher TC1000-2779)
4. Glass wool (Fisher 11-390)

Procedure

1. Uniformly grind a representative sample of potato strips in a blender or conventional food processor.
2. Accurately weigh (to four places) a piece of glass wool (sufficient in size to contain sample pieces in the thimble) and the extraction thimble; record weight of thimble + glass wool (weight "A").
3. Load the ground sample into the thimble and cap the loaded thimble with the pre-weighed piece of glass wool.
4. Accurately weigh (to four places) and record the weight of the ground sample, thimble, + glass wool (weight "B").
5. Place two or more boiling stones into an extraction beaker and weigh (to four places); record weight of extraction beaker + boiling stones (weight "C").
6. Place loaded thimbles on the extraction unit and raise the thimbles to rinse position.
7. Pipette 50 ml of methylene chloride into each pre-weighed extraction beaker with boiling stones.
8. Set oil heating bath to 110°C and water cooling bath to 28.3°C and allow temperatures to equilibrate.
9. Lower the loaded thimbles into the extraction beaker containing the solvent and allow to boil in the solvent for 60 minutes with the condenser's pet cock in the open position.
10. Raise the thimbles to the rinsing position and rinse for 60 minutes.
11. Turn the condenser's pet cock to the closed position and allow the solvent to evaporate for 60 minutes. Turn the nitrogen purging gas on to aid the evaporation.
12. Transfer the beaker to a vacuum oven, pre-warmed to 120°C, for 30 minutes at full vacuum.
13. Allow the beaker to cool to room temperature and weigh (to four places); record the weight of the beaker + boiling stones + extracted fat (weight "D").
14. Calculate percent total fat as follows:

$$\% \text{ Fat} = [(D - C) / (B - A)] \times 100$$

Accordingly, the disclosed embodiments are considered in all respects to be illustrative and not restrictive. The scope of the invention is indicated by the appended claims.

Example 1

Frozen commercial shoestring cut par-fried potato strips are an acceptable starting product (e.g., Simplot Par-Fries, J. R. Simplot Co., Caldwell, ID). A typical processing history may include: sorted and graded Russet Burbank potatoes are peeled, washed, trimmed and cut axially into shoestring strips (0.25 inch by 0.25 inch). The potato strips are blanched in hot water at 150°F to about 178°F (65.5°C to about 81.1°C) for 15-20 minutes and oven dried at 150°F to about 158°F (65.5°C to about 70°C) for 6-7 minutes. The partially dried strips are then par-fried in vegetable oil at 375°F to about 385°F (190.5°C to about 196.1°C) for 30 to 60 seconds. The par-fried potatoes are cooled and frozen at -30°F (-34.4°C), and packaged. The par-fried potato strips have a moisture content of about 64%.

About 1 lb. of the packaged frozen par-fried potato strips are further processed by frying in a 45 lb. oil capacity fryer containing Primex 108 vegetable oil (blend of partially hydrogenated soybean oil and corn oil; available from The Procter & Gamble Co.) for about 3 minutes at a temperature of about 290°F (143.3°C). The resulting par-fries are immediately frozen by immersion in liquid nitrogen for about 20 seconds. The moisture content of the resulting par-fry is about 48% and the fat content is about 14%. Immediately after being frozen the par-fries are enrobed with oil by immersing in liquid oil (conditioned Primex 108) having a temperature of about 335°F (168.3°C) for about 1-3 seconds. The resulting oil enrobed par-fried potato strips are again frozen by immersion in liquid nitrogen. The frozen potato strips are packed into tightly sealed, i.e. airtight, packages and stored at normal freezer temperatures of approximately 0°F (-17.8°C) to about -20°F (-28.9°C). The oil enrobed par-fried potato strips contain about 10% surface fat by weight of the potato strips. The total fat level is about 22% and the bulk moisture level is about 43%.

Example 2

Frozen shoestring-cut par-fried potato strips available to fast food restaurants are obtained for additional processing (e.g., Payette Farms Shoestring Frozen Potatoes, J. R. Simplot Co., Caldwell, ID). It is understood that such conventional frozen potato strips are derived from whole potatoes which have been peeled, cut, water or steam blanched, and possibly dried partially with hot air. The potato strips are thereafter par-fried in vegetable oil for approximately 30-60 seconds at about 375°F (190.5°C) and frozen. The resulting par-fries have a bulk moisture content of about 70%.

The above-mentioned par-fried potato strips are further processed: First, the frozen potato strips are fried a second time by immersing in Primex 108 vegetable oil (available from The Procter & Gamble Co.) for 3 minutes at a temperature of 335°F (168.3°C). The par-fried potato strips are then frozen in

liquid nitrogen for 20 seconds and stored at -20°F (-28.9°C). The resulting frozen par-fried potato strips have a moisture content of about 44% and a fat content of about 15%. The frozen par-fried potato strips are enrobed with oil by immersing in liquid vegetable oil (conditioned Primex 108) having a temperature of about 335°F (168.3°C) for about 1-3 seconds. The oil enrobed par-fries are then frozen by immersion in liquid nitrogen for about 20 seconds. About 10% fat is applied to the surface of the frozen par-fry by this enrobing process. The oil-enrobed par-fried potato strips comprise about 40% bulk moisture and about 23% total fat. The oil enrobed par-fried potato strips are finish baked in a forced air convection oven (Wells Manufacturing Co., Verdi, NV, model #M42003S) at a temperature of about 400°F (204.4°C) for about 2.25 minutes. The resulting fries are virtually identical to fries which are prepared by deep frying.

Example 3

A reduced calorie fat composition is used to prepare the pre-enrobed par-fried potato strips in the following example. The fat composition contains a non-digestible fat component and a "conventional" triglyceride component. The non-digestible fat component comprises a blend of a liquid and solid sucrose polyester (SPE). The non-digestible fat component is added to refined, bleached and deodorized soybean oil and the resulting blend is heated until all the solids are dissolved to provide a fat composition containing 75% SPE and 25% soybean oil.

Russet Burbank potatoes at about 20% potato solids content are peeled, washed and cut into 1/4 inch wide by 3 1/2 inch long potato strips to make shoestring style French fried potatoes. The potato strips are blanched in hot water (140°F; 60°C) for about 5 minutes. The blanched potato strips are allowed to equilibrate at ambient conditions for 5 minutes followed by partial drying in an oven.

The partially dried potato strips are then par-fried in the above-mentioned reduced calorie fat composition for 90 seconds at 375°F (190.5°C), followed by rapid freezing to make frozen par-fries. The frozen par-fries comprise about 55% moisture and about 11% fat. The frozen par-fried potato strips are then enrobed with the reduced calorie fat composition by immersing the par-fried in the fat composition having a temperature of about 335°F (168.3°C) for about 1-3 seconds. The oil enrobed par-fried potato strips are again frozen. The frozen par-fries have about 12% oil coated onto the surface. The oil-enrobed par-fried potato strips comprise about 48% bulk moisture and about 22% total fat. The oil enrobed par-fries are packed into tightly sealed, i.e. airtight, packages and stored at freezer temperatures of about 0°F.



What is claimed is:

1. Oil enrobed par-fried potato strips suitable for oven finishing comprising:
 - (a) from 34% to 58% bulk moisture; and
 - (b) from 8% to 30% total fat;said par-fried potato strips have a substantially uniform surface coating of fat wherein said surface coating comprises from 2% to 15% by weight of said par-fried potato strips.
2. The par-fried potato strips according to Claim 1 wherein said oil enrobed par-fried potato strips are frozen.
3. The oil enrobed par-fried potato strips according to Claim 1 or 2 wherein said fat is a flavored oil or conditioned oil.
4. The oil enrobed par-fried potato strips according to Claim 1, 2, or 3 wherein said fat is selected from the group consisting of soybean oil, corn oil, cottonseed oil, sunflower oil, palm oil, coconut oil, tallow, a non-digestible or reduced calorie fat and mixtures thereof
5. Oil enrobed par-fried potato strips according to Claim 4 wherein said non-digestible fat is selected from the group consisting of sucrose polyesters, polyol fatty acid polyesters or diversely esterified polyol polyesters and mixtures thereof.
6. A process for preparing oil enrobed par-fried potato strips suitable for oven finishing comprising the steps of:
 - a) par-frying potato strips to produce par-fried potato strips having a bulk moisture of from 38% to 58% and a fat content of from 6% to 25%; and
 - b) applying a substantially uniform coating of oil to the surface of said par-fried potato strips to form oil enrobed par-fried potato strips wherein said surface coating comprises from 2% to 15% by weight of the oil enrobed par-fried potato strips;said oil enrobed par-fried potato strips have from 34% to 54% bulk moisture and from 8% to 30% total fat.
7. The process of Claim 6 wherein the oil coating step (b) is preceded by reducing the temperature of the par-fried potato strips, preferably wherein the temperature reducing step comprises promptly and substantially freezing the par-fried potato strips to a temperature below -17.8°C.



8. A process for preparing oil enrobed par-fried potato strips suitable for oven finishing comprising the steps of:

- a) par-frying potato strips in oil;
- b) reducing the temperature of the once par-fried potato strips;
- c) par frying the temperature reduced par fried potato strips a second time to produce par-fried potato strips having a bulk moisture of from 38% to 58% and a fat content of from 6% to 25%; and
- d) applying a substantially uniform coating of oil to the surface of said par-fried potato strips to form oil enrobed par-fried potato strips wherein said surface coating comprises from 2% to 15% by weight of the oil enrobed par-fried potato strips;

said oil enrobed par-fried potato strips have from 34% to 54% bulk moisture and from 8% to 30% total fat.

9. The process of Claim 8 wherein the oil coating step (d) is preceded by reducing the temperature of the par-fried potato strips.

10. An oil-enrobed par-fried potato strip according to Claim 1, 2, 3 or 4 wherein said oil-enrobed prebake par-fries are characterized by the following thermal properties at oven finishing temperatures:

- (a) thermal conductivity of the crust region of from 0.1 to 0.3 watts/m°C;
- (b) thermal conductivity of the interior starch matrix core of from 0.4 to 0.7 watts/m°C; and
- (c) surface heat transfer coefficient of from 50 to 400 watts/m²°C.

11. An oil-enrobed par-fried potato strip according to Claim 10 wherein the fat in the oil enrobed par-fried potato strips has a free fatty acid level of less than 0.8%.

12. A process according to claim 6 or 7 wherein said oil-enrobed par-fries are characterized by the following thermal properties at oven finishing temperatures:

- (a) thermal conductivity of the crust region of from 0.1 to 0.3 watts/m°C;
- (b) thermal conductivity of the interior starch matrix core of from 0.4 to 0.7 watts/m°C; and
- (c) surface heat transfer coefficient of from 50 to 400 watts/m²°C.



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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶: A23L 1/217, A23P 1/08	A1	(11) International Publication Number: ☒ WO 97/40712 (43) International Publication Date: 6 November 1997 (06.11.97)
(21) International Application Number: ☒ PCT/US97/06396 (22) International Filing Date: ☒ 16 April 1997 (16.04.97) (30) Priority Data: 08/639,542 ☒ 29 April 1996 (29.04.96) ☒ US (71) Applicant: THE PROCTER & GAMBLE COMPANY [US/US]; One Procter & Gamble Plaza, Cincinnati, OH 45202 (US). (72) Inventors: ELSEN, Joseph, James; 2807 Montana Avenue, Cincinnati, OH 45211 (US). KESTER, Jeffrey, John; 6704 Timberwood Drive, West Chester, OH 45069 (US). WALSH, Belle, Cromwell; 5661 Regimental Place, Cincinnati, OH 45239 (US). CORRIGAN, Patrick, Joseph; 33 Dexter Park Boulevard, Cincinnati, OH 45241 (US). TAYLOR, Kyle, McLennan; 8711 Simpson Court, Mason, OH 45040 (US). PAPA, Alyce, Johnson; 224 Brocdorf Drive, Cincinnati, OH 45215 (US). (74) Agents: REED, T., David et al.; The Procter & Gamble Company, 5299 Spring Grove Avenue, Cincinnati, OH 45217 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, <u>SG</u> , SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: OIL ENROBED PAR-FRIED POTATO STRIPS ☒ (57) Abstract Disclosed are oil enrobed par-fried potato strips suitable for oven finishing comprising: (a) par-fried potato strips having from about 34 % to about 58 % bulk moisture; and (b) from about 8 % to about 30 % fat. The par-fried potato strips have a substantially uniform surface coating of oil or fat. The surface coating comprises from about 2 % to about 15 % by weight of said par-fried potato strips. When oven finished, the oil enrobed par-fried potato strips have substantially the same taste, quality and characteristics as French fries that have been deep fried.		