

OVEN-BAKED FRENCH FRIES HAVING DEEP-FRIED TASTE AND TEXTURE

BACKGROUND OF THE INVENTION

The present invention relates to French fried potatoes baked in an oven. More particularly, it relates to oven-finished French fried potatoes that approximate the attributes and characteristics of French fries that have been finished by deep fat frying.

French fried potatoes are one of the most popular convenience foods whether they are prepared at home or purchased from fast food restaurants. Deep-fried French fries are particularly well liked by virtue of their textural dichotomy. This textural dichotomy manifests itself in a product which has a fairly crisp exterior and a fairly tender and moist interior. The method of deep frying has been found to be a particularly suitable way for imparting this desired textural dichotomy to French fried potatoes.

Recent attention has been directed to the use of ovens for preparing French fries from the partially fried (herein after par-fried) frozen state. The prior art oven-finished products are by no means equivalent to deep fried French fries. This is because during oven finishing, moisture migrates from the internal core outward to the crust region. This tends to make the oven-finished French fries limp, i.e., the fries lack surface crispness.

Attempts to improve the texture by longer heating time, higher oven temperature, rapid heating (e.g., microwave), etc. have generally been unable to provide the desired balance of moist interior encased by a low-moisture, crisp crust. Generally, the French fries produced are leathery, dry and tough. Examples of some methods for altering the par-fries and/or methods to produce fully cooked fries, which upon oven-finishing or oven reheating generally result in French fries having poor textural qualities (i.e., dry interiors and tough or soggy exterior crusts), can be found in the prior art, see for example, U.S. 5,000,970 (Shanbhag et al.), U.S. 5,302,410 (Calder et al.), U.S. 3,865,964 (Kellermeier) and U.S. 5,242,699 (Bednar et al.). The poor textural qualities affect the palatability of the oven-finished product. Thus, a great demand exists today for French fried potatoes that are oven-finished and that, in the ready-to-eat state, have the color, texture, mouthfeel and taste of deep fried French fries.

The oven-finished French fries of the present invention provide one or more advantages in relation to the organoleptic properties, specifically the crust crispness and the moistness of the internal core. The oven finished fries have substantially the same textural dichotomy as deep-fried French fries. The external surface (i.e., crust) is moderately crisp and not excessively oily and the interior portion (i.e., core) is well cooked, tender, mealy and moist, yet free from sogginess.

The oven-finished French fries of the present invention can be differentiated from commercial and prior art oven-finished French fries in that they possess a combination of attributes, in particular, bulk moisture, total fat, internal moisture content, surface water activity (A_w) and Texture Value, that renders them virtually indistinguishable from deep fried French fries. The oven-finished French fries of the

present invention can also be differentiated from commercial oven fries based on subjective evaluations (i.e., expert sensory panelists).

It is therefore an objective of the present invention to provide oven-finished French fries that are significantly preferred over commercial and prior art oven finished products on the basis of taste/eating satisfaction and that are parity in taste with deep fried French fries.

It is also an objective of the present invention to provide oven-finished French fries which are virtually indistinguishable from deep-fat fried French fried potatoes which may be purchased in fast food restaurants.

It is further an objective of the present invention to provide oven finished French fries which have a moist interior surrounded by a crisp yet tender outer surface.

These and other objectives of the present invention will be made clear by the disclosure herein.

All percentages are by weight unless otherwise indicated.

SUMMARY OF THE INVENTION

The present invention relates to oven-finished French fried potatoes comprising:

- a) from about 32% to about 50% bulk moisture;
- b) from about 8% to about 25% total fat;
- c) from about 55% to about 80% internal moisture content;
- d) a surface water activity (Aw) of less than or equal to about 0.55; and
- e) a Texture Value of at least about 200; wherein said Texture Value is the maximum force (grams) or the area (gram sec) under the force deformation curve during the first one-third of a compression test.

The oven finished French fries have a texture which is virtually indistinguishable from commercial French fries that have been prepared by deep fat frying such as McDonald'sTM French fries.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is concerned primarily with the attributes of oven finished French fries. The present invention further relates to oven finished French fries which are ready to eat, and are virtually indistinguishable from deep-fried French fries.

Definitions

As used herein the term "deep fried French fries" refers to potato strips which have been cooked to a ready-to-eat form by immersion in hot oil.

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 convection oven, high air velocity oven, hot air impingement oven, infrared oven, combined convection/infrared oven, microwave oven, combined microwave/convection oven or a conventional home oven. Typically, cooking entails reducing the moisture content of the food.

As used herein the term "fat" or "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, canola oil, sunflower oil, palm oil, coconut 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.

As used herein the term "finished" refers to a product that has been subjected to a cooking process to convert it to a ready-to-eat form.

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.

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.

As used herein the term "oven baking" refers to baking in an oven such as a forced air convection oven, hot air impingement oven, infrared oven, a combination of infrared radiation and convection oven, a toaster, toaster oven, a microwave oven, a combination microwave and forced air convection oven, or a conventional home oven.

As used herein the term "Texture Value" is the maximum force (grams) or the area (gram sec) under the force deformation curve recorded during the first one-third of a compression test (see section on analytical test methods for more details).

OVEN-FINISHED FRENCH FRIES

The critical features of the present invention are the Texture Value, the bulk moisture, the internal moisture content, the surface Aw, and the amount of fat present in the oven-finished product. Importantly, it is the combination of these attributes and not a single attribute that distinguishes the present invention from commercial and prior art oven-finished fries and renders them virtually indistinguishable from deep fried French fries.

The distinguishing features of the present invention reside in part in the recognition of critical physical characteristics of the par-fries and their thermal properties wherein this relationship can be used to insure oven-finished French fries having moist interiors and crisp crusts for a variety of different oven-finishing processes. More particularly, the present invention recognizes that for oven-finished French fries, a certain range of values for surface Aw and Texture Value are required for optimum palatability.

One embodiment of the present invention is the par-fried potato strips which may be prepared by processing steps known in the art. The par-fries may be prepared from a variety of raw potatoes known to be suitable for preparing French fries. Preferably the par-fried potato strips are prepared from potatoes of the Russet Burbank, Shepody or Katahdin varieties. The par-fried strips may be of varying shapes and sizes. However, it is preferred that the relatively thin and elongated 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 to about 5 inches in length. Thicker-cut potato strips may also be used herein; e.g., "crinkle cut" strips, straight cut thick potato strips (also known as "regular-cut") and "steak fry" cuts.

The potato strips are blanched according to conventional procedures known in the art. Following blanching, the potato strips may be subjected to additional treatments known in the art. For instance, the potato strips may be treated with sodium acid pyrophosphate (SAPP), a chelating agent used to prevent discoloration of the strips. Dextrose (corn syrup) may also be applied to the surface of the strips in order to yield a desired level of brown color development during subsequent processing. In addition, the potato strips may be optionally dried partially to reduce their moisture content. The potato strips are then subjected to one or more frying processes at an oil temperature of from about 270°F (132°C) to about 385°F (196°C). The frying process may involve immersion of the potato strips in oil, a heated oil spray which surrounds the potato strip with hot oil, or frying using an oil foam. In a preferred embodiment, the blanched potato strips are reduced in moisture to a moisture content of not less than about 60%, after which they are fried at an oil temperature of from about 270°F (132°C) to about 335°F (168°C) for a time sufficient to produce par-fries comprising about 30% to about 58% moisture. After frying, the par-fries may be immediately cooled or frozen. Chilling or freezing of the par-fries may be accomplished by methods known in the art. Multiple frying, chilling, and/or freezing steps may be employed during processing of the par-fries. The par-fries may also be treated with various surface treatments (e.g., enrobed with oil; application of hydrocolloid coating; application of water, aqueous solution, or dispersion; etc.) either before or after cooling or freezing. The par-fries may be stored frozen at temperatures between about -70°F (-57°C) and about 20°F (-6.7°C).

The moisture, and fat content and thermal properties of the par-fries are important to produce the oven baked fries of this invention. Of particular importance is the distribution of water in the par-fry and the control of water migration from the internal core to the crust region of the par-fries during storage and oven finishing. By controlling moisture transfer from the internal core to the crust region during frozen storage and oven-finishing, ready-to-eat oven-baked French fries can be prepared that possess a highly palatable moist interior surrounded by a low-moisture, crisp crust region. The textural dichotomy that results in the oven-finished fry is very similar to that which exists in French fries that are finished by deep frying.

Moisture migration from the internal core to the crust region during frozen storage can be partially controlled by frying the potato strips to bulk moisture contents that are preferably equal to or greater than about 40%, more preferably equal to or greater than about 42%, and most preferably equal to or greater than about 44%. Moisture migration can also be minimized during frozen storage by hydrating the crust region prior to frozen storage in order to increase the crust A_w and, thereby, reduce or eliminate the A_w differential between the internal core and the crust, which is the driving force for moisture transfer. Hydration of the crust region can be accomplished by application of water, a water mist, an aqueous solution, or an aqueous dispersion to the surface of the par-fry. Preferably a spraying process is used to hydrate the crust region of the par-fries.

Moisture migration from the internal core to the crust region during oven finishing can be minimized by employing oven-finishing conditions that rapidly and/or preferentially dry the surface of the French fry. This can be achieved by selecting oven conditions (temperature, air velocity) that yield a relatively high surface heat transfer coefficient at oven temperature. Higher surface heat transfer coefficients are desirable because this will lead to faster cooking time and the formation of a more distinct and crisp low-moisture crust region. Preferable surface heat transfer coefficients at oven temperature are from about 50 to about 400 watts/m²°C. Preferential drying of the surface of the par-fry can also be achieved by enrobing the par-fries with an edible fat or oil, which increases the conduction of heat from the surrounding air to the fry surface during oven baking. Desired thermal conductivities at oven temperatures of the crust region of the par-fry are from about 0.1 to about 0.3 watts/m°C. Desired thermal conductivities of the high-moisture internal core are from about 0.4 to about 0.7 watts/m°C. Enrobing par-fries with fat or oil also serves the purpose of providing an added barrier to moisture loss from the internal core as the enrobing oil is partially absorbed into the outer crust region during baking. The surface of the par-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 par-fry surface.

Thermal conductivities and surface heat transfer coefficients can be calculated as follows.

Surface heat transfer coefficient

The general equation for heat transfer across an interface is well known:

$Q_t = UA (T_2 - T_1) - \Delta H_w + Q_r$ where:

Q_t = amount of heat transferred across the boundary (watts, or equivalent energy unit).

U = surface heat transfer coefficient (watts/m² °C or equivalent)

A = surface area of the boundary region (m² or equivalent)

T_2 = Temperature on the hot side of the boundary (°C or equivalent)

T_1 = Temperature on the cooler side of the boundary (°C or equivalent)

ΔH_w = heat lost due to evaporation of water from the surface

Q_r = radiative heat transfer = $AF\sigma(T_2^4 - T_1^4)$ where F is the shape factor and σ is the Stefan-Boltzman constant.

A careful measurement of temperature on either side of the boundary versus time as well as the moisture level on either side of the boundary versus time, and the temperature of any infrared heating source to which the surface is directly exposed will allow calculation of the surface heat transfer coefficient (U).

Thermal Conductivity

Thermal conductivity for a food material with a crust can be calculated once U , T_2 and T_1 are known.

$$k = UL(T_2 - T_1)/(T_1 - T_i)$$

k = thermal conductivity (W/m-°C or equivalent)

L = crust thickness (m or equivalent)

T_i = reference temperature

While not wishing to be bound by theory, it is believed that prior art oven fries lack the desirable textural dichotomy associated with high-quality deep-fried French fries because the par-fry attributes (moisture; fat; surface fat; thermal properties) and oven-finishing conditions are not optimized for producing a finished oven fry with a moist interior and a crisp low-moisture crust. For example, many commercial or prior art par-fries are so high in moisture content that upon the recommended oven baking the oven-finished fry is not sufficiently low in bulk moisture content or the crust region has not been sufficiently dehydrated to yield a crisp surface texture. While using more rigorous oven conditions may remove water from the surface of the fries and may improve the crispness of the crust, excessive internal moisture transfer from the internal core to the surface often occurs simultaneously, resulting in oven-finished French fries having one or more of the following textural deficiencies: a tough surface texture; an interior that is perceived as excessively dry; and/or an excessively crunchy overall texture (i.e., the oven-finished fries do not possess the desired textural dichotomy associated with deep fried French fries).

Other methods may also be used to control water migration and water distribution of the par-fries. However the preferred method, as described above, comprises controlling the bulk moisture and thermal properties (i.e., thermal conductivity of the high-moisture internal core, thermal conductivity of the crust region, and the surface heat transfer coefficient) of the par-fries. The bulk moisture of the par-fries may be controlled by the process conditions used in producing the par-fries; e.g., the conditions used for dehydrating the potato strips before frying; the par-frying conditions; and the level, if any, of surface hydration of the par-fries. The thermal properties of the par-fries may be modified likewise and additionally may be modified by application of various ingredients onto the surface of the par-fries (e.g., enrobing with oil; coating with hydrocolloids; etc.).

The par-fries useful in the present invention have a bulk moisture of greater than about 30%. Typically the bulk moisture is from about 38% to about 58%, preferably from about 40% to about 56%, more preferably from about 42% to about 54% and even more preferably from about 44% to about 50% bulk moisture.

The bulk moisture and thermal properties of the par-fries provide a method for controlling moisture loss from par-fried potato strips during oven finishing such that the resulting French Fries have substantially the same textural dichotomy as deep fried French fries. Further, the bulk moisture and thermal properties of the par-fries indicate how the par-fry processing conditions and oven-finishing conditions may be altered to insure optimum textural characteristics in the oven-finished French fry.

Another embodiment of the present invention is the oven-finished French fries. The oven-finished French fries of the present invention may be baked in various types of ovens, including a forced air convection oven, hot air impingement oven, infrared oven, a combination of infrared radiation and convection oven, a toaster, a toaster oven, a microwave oven, a combination microwave and forced air convection oven, or a conventional home oven. The baking time is less than or equal to about 15 minutes, preferably less than or equal to about 10 minutes, more preferably less than or equal to about 5 minutes, and most preferably less than or equal to about 3 minutes. Upon removal from the oven, the baked fries may optionally be coated with oil to further enhance flavor and mouthfeel. Preferably the oil used for coating the baked fries is a flavored or conditioned oil. The oil may be applied to the surface of the baked fries by methods known in the art; e.g., by spraying warm oil onto the surface or by rapid immersion of the fries into a reservoir of warm oil. The oven-finished French fries of the present invention can be differentiated from commercial and prior art oven-finished French fries in that they possess a combination of attributes, in particular, a certain Texture Value, bulk moisture, internal moisture, surface Aw, and total fat that renders them virtually indistinguishable from French fries that have been finished by deep-fat frying. Further, the oven-finished French fries of the present invention can be differentiated from commercial and prior art oven-finished French fries based on subjective evaluation (i.e., expert sensory panelists).

Texture Value

A critical attribute of the present invention is the Texture Value of the oven-finished French fries. This value is dependent on a combination of factors such as moisture content, crispness of the crust, degree of dehydration of the crust, and other physical properties of the fries. The Texture Value is determined by the use of a Texture Analyzer equipped with a rectangular, blunt steel plate probe. A compression test is run in which the plate compresses the French fry while the force of resistance is measured (see section on analytical test methods for details). The force (grams) vs. time (sec) data is plotted to produce a force deformation curve. Two textural parameters obtained from the force deformation curves are used to characterize the texture of French fries, average maximum force (grams)

and average area (gram sec) within the first 1/3 of the compression test. We have found both of these parameters to correlate with the crispness of French fries and either one may be designated as the Texture Value. High quality oven-finished French fries of the present invention exhibit distinctive textural dichotomy and are characterized by a Texture Value (i.e., maximum force or area) of at least about 200. Preferably the Texture Value is from about 210 to about 1000, more preferably from about 220 to about 600, and even more preferably from about 240 to about 500. Further, the oven-finished French fries of the present invention have a ratio of the average area to the average maximum force of at least 1.0, preferably 1.04 or greater, more preferably 1.08 or greater, even more preferably 1.12 or greater, and most preferably 1.16 or greater. Commercial oven-finished fries prepared according to the manufacturer's oven instructions lack dichotomous textural characteristics as found in the fries of the present invention. Typically the average maximum force (grams) and the average area (gram sec) for commercial and prior-art oven fries are below 200 and the ratio of the average area to the average maximum force is about 1.0 or less.

Over-cooked commercial oven fries may exhibit an average maximum force or area of at least about 200 or greater. However, the oven-finished fries of the present invention can be distinguished from the overcooked commercial oven fries based on the bulk and/or internal moisture and based on the fact that the ratio of the average area to the average maximum force of the overcooked commercial oven fries generally remains at about 1.0 or less.

Bulk Moisture

Another critical attribute of the present invention is the bulk moisture content of the oven-finished French fries. Bulk moisture is the total amount of water in the fries of the present invention. The oven-finished French fries of the present invention have a bulk moisture of from about 32% to about 50%. Shoestring cut, oven-finished French fries of the present invention have a bulk moisture of from about 32% to about 46%. Preferably the bulk moisture of shoestring-cut, oven-finished French fries should be from about 33% to about 44%, and more preferably the bulk moisture should be from about 34% to about 40%. Thicker-cut oven-finished French fries of the present invention (e.g. regular cut, crinkle-cut and steak fries) typically have a bulk moisture of from about 35% to about 50%. Preferably the thicker-cut oven-finished French fries have a bulk moisture of from about 38% to about 48% and more preferably from about 40% to about 46%. The bulk moisture of the products herein can be measured using well-known techniques and commercially available instruments. An oven-finished French fry with a bulk moisture much greater than about 50% will not have developed a sufficient crust structure to yield the desired textural dichotomy (i.e., the fries will lack crispness). At a bulk moisture much less than about 32% the oven-finished fries can become too dry. Keeping the bulk moisture of the oven-finished fries of the present invention at a level between about 32% and 50% allows production of oven fries that possess both a low-moisture, crisp crust region as well as a high-moisture internal core.

Internal Moisture

The internal moisture content is also an important characteristic of the present invention. The internal moisture content of oven-finished French fries is the moisture content of the interior starch matrix. As mentioned before the interior portion (i.e., core) is well cooked, tender, mealy and moist, yet free from sogginess. The oven-finished French fries of the present invention have an internal moisture of from about 55% to about 80%, preferably from about 60% to about 77%, more preferably from about 63% to about 75%.

Surface A_w of the Crust

A distinguishing characteristic of the oven-finished fries of the present invention is the exterior crust. The exterior crust is comprised of dehydrated gelatinized starch and oil or fat. Preferably, the exterior crust has substantially the same composition as the crust of deep fried French fries made from raw potatoes. However, the crust may contain ingredients typically applied to the surface of potato strips such as starches, hydrocolloids, gums, flavorings and the like.

It is important that the outer crust region is crisp and relatively low in water activity (A_w). The texture of fried and baked food products is known to be related in part to the A_w of the product. Crisp textures are generally associated with A_w values less than or equal to about 0.55. The surface A_w is a measurement of the water activity of the crust region of the oven-finished French fries (see section on analytical test methods for details concerning surface A_w measurement). The surface A_w is equal to the vapor pressure of water in the outer crust region divided by the vapor pressure of pure water at the same temperature.

The oven-finished French fries of the present invention preferably have a surface A_w of less than or equal to about 0.55, preferably from about 0.10 to about 0.52, more preferably from about 0.15 to about 0.5, and even more preferably from about 0.2 to about 0.45.

Total Fat

Edible oil, natural or synthetic, is generally on the surface and within the crust region of the oven-finished French fry of the type disclosed in the present invention. Edible oils contribute to the flavor, lubricity and texture of the oven-finished French fry. The edible oils or fats present on the surface and within the crust region of the oven-finished French fry are well known by one skilled in the art and 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. 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.)

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 present on the surface and/or within the crust region of the oven-finished French fries.

Some preferred oils are soybean oil and corn oil. The total amount of oil or fat present in and on the oven-finished French fries of the present invention is from about 8% to about 25%. Shoestring French fries of the present invention typically have from about 12% to about 25% total fat, preferably from about 13% to about 23% fat, and more preferably from about 14% to about 20% total fat. Thicker-cut oven-finished French fries (e.g. regular cut, crinkle-cut and steak fries) typically have a total fat level of from about 8% to about 22%. Preferably the thicker-cut oven-finished French fries have a total fat level of from about 10% to about 20%, and more preferably from about 12% to about 18%.

Preferably the edible fat or oil present on the surface and within the crust region of the oven-finished French fries of the present invention has a free fatty acid level of about 0.8% or less.

Additional Ingredients

Flavoring agents, such as salt, pepper, butter, onion, or garlic may be added to the par-fries or the oven-finished fries 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/or enrobe the par-fried potato strips, including antioxidants such as TBHQ, chelating agents such as citric acid, and antifoaming agents such as dimethylpolysiloxane.

The oven-finished French fries of the present invention can also be distinguished from commercial and prior-art oven fries based on sensory evaluation and Nuclear Magnetic Resonance (NMR) Imaging. Sensory evaluation reveals that the oven-finished French fries of the present invention possess a desirable textural dichotomy (i.e., a crisp surface surrounding a moist interior) typically associated with deep-fried French fries. Commercial and prior-art oven fries do not typically display this desired textural dichotomy. NMR imaging provides a cross-sectional image depicting the moisture and fat distribution within the fries. The high-quality oven-finished French fries of the present invention are characterized by NMR images that appear qualitatively similar to the images of deep-fried French fries, i.e., both products are characterized by images that reveal a high moisture internal core surrounded by a low moisture crust region that contains the fat. In contrast, NMR images of commercial oven fries typically appear qualitatively different; i.e., the dichotomous feature of a low-moisture crust surrounding a high-moisture core is not as readily apparent.

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.

ANALYTICAL TEST METHODS

A number of parameters are used to characterize elements of the par-fried potato strips and the oven-finished French fries of the present invention. They are quantified by particular experimental analytical procedures. Each of these procedures is described in detail as follows:

Bulk Moisture Content Test

Moisture content of par-fried potato strips and finished French fries is determined by a forced air oven method as follows:

1. Uniformly grind up a representative sample of potato strips or French fries in a blender or conventional food processor.
2. Accurately weigh approximately 5 grams of ground sample (weight "A") into a previously tared 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:

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

French Fry Texture Value Test

The Texture Value of finished French fries, which correlates with crispness of the fries, is measured with a TA-XT2 Texture Analyzer (version 05.16 equipped with 25-l load cell, Texture Technologies Corp., Scarsdale, NY). The Texture Analyzer is linked to a standard personal computer (e.g. IBM 433DX) that records the data via a software program called XT.RA Dimension (version 3.7H, Texture Technologies Corp., Scarsdale, NY).

The Texture Analyzer is configured with a rectangular, blunt steel plate probe (2.5-3.0 mm thickness, 70 mm width, 90 mm length) that is fastened vertically to the main arm. A "Compression Test" on a single French fry will be run to generate a plot of Force (grams) vs. Time (sec), from which the Texture Value is obtained.

Procedure for Set-up and Calibration of the Texture Analyzer**1. Set-up the Texture Analyzer as follows:**

Mode:	Measure Force in Compression
Option:	Return to Start
Force Units:	Grams
Time Units:	Seconds
Distance Format:	Strain
Pre-Test Speed:	2.0 mm/sec
Probe Test Speed:	1.0 mm/sec
Post-Test Speed:	10 mm/sec
Strain:	85.0%
Trigger Type:	Auto 10

2. Set the texture method as follows:

Graph Type:	Force vs. Time
Auto-Scaling:	Off
Force Scaling Max:	5000 grams
Force Scaling Min:	0 grams
Peak Confirmation:	On
Force Threshold:	20 grams
File Type:	Lotus 1-2-3
Display and Export:	Plotted points
Acquisition Rate:	200 pps
Force Units:	Grams
Contact Area:	1.00 mm ²
Contact Force:	5.0 grams

- 3. Calibrate the force by placing a 5 kg weight on the calibration platform and press the "calibrate" button on the Texture Analyzer key pad.**
- 4. Calibrate the probe distance from the base plate with a probe starting distance from the plate of 10 mm for shoestring-cut fries (increase probe starting distance to 15 mm for thick-cut or steak fries). Ensure that the bottom surface of the probe is parallel to the surface of the base plate.**

Procedure for Sample Measurements

- 1. Immediately following removal of finish-cooked French fries from a fryer (deep-fried) or oven (oven-baked), place the batch of fries under a heat lamp for 1 minute prior to beginning the texture**

analysis. The air temperature under the heat lamp is between about 130°F and about 180°F (about 54.3°C to about 82.2°C).

2. After the 1 minute hold time has elapsed, place a single French fry flat on the base plate of the Texture Analyzer (oriented perpendicular to the probe width). Initiate the Compression Test (1.0 mm/sec probe speed) while manually holding the ends of the French fry flush against the base plate.

3. The resulting Force (grams) vs. Time (sec) data is saved for later analysis. Nine additional fry samples from the same batch are tested in an identical manner. The ten fry samples from each batch are selected randomly. Texture analysis of the ten fry samples should be completed within 3-4 minutes. (3-4 minutes after Step 1).

4. Steps #1-#3 are repeated for each new batch of French fries. Generally, 5 to 10 batches of each type of French fry are evaluated in this manner.

Data Analysis

1. The "Force vs. Time" plot for each individual French fry sample is evaluated for the following:
 - Maximum Force (grams) within the first 1/3 of the test.
 - Area (gram sec) under the curve within the first 1/3 of the test.
(e.g. if the Compression Test requires 6 seconds to complete, the Maximum Force and Area are obtained from the 0-2 second time period)
2. After analysis of the "Force vs. Time" data for all ten French fry samples selected from a given batch, the ten Maximum Force values are averaged and the ten Area values are averaged. A computer program written in Excel automates the task of analyzing the Force vs. Time data for each fry sample and averaging the Maximum Force and Area values for each batch of fries.
3. Remaining batches of a particular French fry type are analyzed in a similar manner (5-10 batches are tested; 10 fries/batch are analyzed). The Maximum Force and Area values for each batch are then averaged to yield an overall average Maximum Force (grams) and Area (gram sec) for that particular fry type.
4. For the purpose of this invention, either the overall average Maximum Force or Area may be designated as the French fry Texture Value. Both texture measurements correlate to crispness of finished French fries.

Determination of the Internal Moisture Content of French Fries

Internal moisture content of finished French fries, i.e. moisture content of the interior starch matrix, is determined as follows:

1. Immediately following removal of finish-cooked French fries from a fryer (deep-fried) or oven (oven-baked), immerse the fries in liquid N₂ for 20 seconds to completely freeze the products and stabilize the internal moisture distribution.
2. Store the frozen French fries at about -112°F (-80°C) until analysis.
3. Remove several fries from the freezer and place on a stainless steel tray. Allow the fries to warm slightly for several minutes at room temperature to facilitate removal of the crust.
4. Carefully cut off the crust on one side of each frozen fry with a razor blade. Rotate the fries and repeat this procedure until the crust has been removed from all four sides.
5. Collect the frozen interior starch matrix (white solidified material) and immediately place in a capped glass vial. Take care only to collect the interior starch matrix; do not include any crust remnants.
6. Repeat steps #3-#5 until approximately 5 grams of frozen interior starch matrix is collected. This may require about 15-20 fries.
7. Accurately weigh approximately 5 grams of the interior starch matrix (weight "A") into a previously tared metal pan or dish.
8. Place the metal dish containing the interior starch matrix in a forced air convection oven at 105° C for 2 hours.
9. 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.
10. Re-weigh the dish containing the dried sample and calculate the weight of the dried sample (weight "B") by subtracting the dish tare weight.
11. Calculate the percent moisture of the interior starch matrix as follows:
$$\% \text{ internal moisture} = [(A - B) / (A)] \times 100$$

Determination of the Surface Water Activity (A_w) of French Fries

Surface A_w of finished French fries is determined as follows:

1. Immediately following removal of finish-cooked French fries from a fryer (deep-fried) or oven (oven-baked), immerse the fries in liquid N₂ for 20 seconds to completely freeze the products and stabilize the internal moisture distribution.
2. Store the frozen French fries at about -112°F (-80°C) until analysis.
3. Transfer a bag of French fries (~0.5-1 lb.) from the -112°F (-80°C) freezer to a cooler containing dry ice; ensure the bag is thoroughly packed in dry ice in order to maintain the fries in a frozen state at low temperature.

4. Remove one French fry at a time from the sample bag and rapidly scrape the surface of the fry with a single-edged razor blade. Collect the surface shavings onto a stainless steel tray and immediately transfer the shavings to a capped glass vial.

Take care only to collect surface shavings from the outer crust region of the French fry; do not scrape so hard such that the crust region is penetrated and the interior starch matrix core is exposed.

5. Repeat step #4 until approximately 0.3-0.7 gram of surface shavings is collected; this will require scraping about 10-20 frozen fries.

6. Determine the water activity (A_w) of the surface shavings using a Rotronic Hygroskop Model DT relative humidity meter (Rotronic Instrument Corp., Huntington, NY), as follows:

- a. Transfer the surface shavings to a plastic A_w dish (Rotronic Instrument Corp.).
- b. Immediately place the A_w dish containing the surface shavings into one of the humidity cells of the Hygroskop Model DT relative humidity meter and close the cell cover tightly.
- c. Allow the meter reading to stabilize (wait 1 hour or longer) before recording the reading and temperature.
- d. Convert the stabilized meter reading to % Relative Humidity (RH) using a previously prepared calibration graph (meter reading vs. %RH) prepared with the following RH standards:

11% RH	Saturated solution of Lithium Chloride (see Greenspan, L., 1977, J. Res. Natl. Bur. Stand., Section A, 81A:89)
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35% RH	Standard solution from Rotronic Instrument Corp.
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50% RH	Standard solution from Rotronic Instrument Corp.
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65% RH	Standard solution from Rotronic Instrument Corp.
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- e. Convert %RH of the surface shavings to Surface A_w as follows:

Surface $A_w = [\%RH / 100]$.

Total Fat Content Test

Total fat content of par-fried potato strips, and finished French fries 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 or French fries 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 (about 30 mm Hg pressure or less).
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:

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

EXAMPLES

Example 1

Two oven-finished French fry products and one deep-fried French fry product are prepared as follows:

A. Oven-finished French fries according to the present invention:

Frozen 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 square cross-section). The potato strips are blanched in hot water or steam and partially dried with hot air such that the potato strips are reduced in weight by about 15%. The partially dried strips are then par-fried in partially-hydrogenated soybean oil (Iodine Value of about 67) for about 50 seconds at an oil temperature of about 375°F (190.5°C). The par-fried potato strips are then cooled and frozen in a blast freezer at -30°F (-34.4°C) and packaged. The par-fried potato strips have a moisture content of about 64% and a fat content of about 6%.

About 1 lb. of the frozen par-fried potato strips are further processed by deep frying in a 45 lb. oil capacity foodservice frying kettle 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 20 seconds. The moisture content of the resulting par-fry is about 47% and the fat content is about 15%. Immediately after being frozen the par-fries are enrobed with oil by immersing in liquid vegetable oil (conditioned Primex 108) having a temperature of about 335°F (~168°C) for about 1-3 seconds. The resulting oil-enrobed par-fries are again frozen by immersion in liquid nitrogen. The frozen par-fries are packed into sealed foil-laminate bags and stored at normal freezer temperatures of approximately 0°F (-18°C) to about -20°F (-29°C). The oil-enrobed par-fries contain about 9% surface fat by weight of the fries. The total fat level is about 22% and the bulk moisture level is about 43%.

About 128 grams of the above frozen oil-enrobed par-fries are placed on an open wire mesh oven tray in a single layer and then baked at a temperature of about 400°F (204°C) in a forced air convection oven (Wells Manufacturing Co.; Model No. M42003S) for about 1 minute. Then the fries are transferred

to a solid stainless steel oven tray in a single layer and baked an additional 1.5 minutes. A turbulent hot airflow exists within the oven chamber. The air velocity at the center of the oven chamber (immediately above the product bed) is about 900 feet per minute (274 meters per minute). Upon removal from the oven, the fries are immediately evaluated for various technical attributes or are salted and evaluated for flavor and texture by sensory testing.

B. Commercial oven-finished French fries:

Frozen retail Ore-Ida® "Shoestrings" French fried potatoes (Ore-Ida Foods, Inc., Boise, ID) are purchased at a local grocery store. The fries comprise about 63% moisture and about 6% fat. The fries are baked in a conventional home oven (General Electric) as follows: approximately 8 oz. of frozen fries are spread uniformly in a single layer over a 9" x 13" solid cooking sheet and baked for about 10 minutes at a temperature of about 450°F (232°C). Upon removal from the oven, the fries are immediately evaluated for various technical attributes or are salted and evaluated for flavor and texture by sensory testing.

C. Deep-fried French fries (McDonald's™ French fries; "gold standard"):

The frozen shoestring-cut par-fried potato strips used as the starting par-fry for preparation of product "A" of this example (Simplot Par-fries; J. R. Simplot Co.; Caldwell, ID) are further processed by deep-frying. The par-fried potato strips have a moisture content of about 64% and a fat content of about 6%.

About 1.5 lb. of the frozen par-fried potato strips are allowed to thaw for about 1 hour at room temperature (70°F; 21.1°C) and then are deep-fried in a 45 lb. foodservice frying kettle containing conditioned Primex 108 vegetable oil (blend of partially hydrogenated soybean oil and corn oil available from the Procter & Gamble Co.) for about 3 minutes at an oil temperature of about 335°F (168°C). Upon removal from the fryer, the deep-fried French fries are immediately evaluated for various technical attributes or are salted and evaluated for flavor and texture by sensory testing.

The above French fry products (A, B and C) are evaluated for bulk moisture, total fat, internal moisture content, surface Aw and Texture Value. The results are shown in the following table:

Product		Bulk Moisture	Total Fat	Internal Moisture	Surface Aw	Max. Force	Area	Ratio Area to Max. Force
A	Oven Fry-Present Invention	38%	18%	67%	0.3	205 g	243 g sec	1.19
B	Oven Fry-Commercial	48%	9%	72%	0.6	133 g	113 g sec	0.85
C	Deep Fry-Gold Standard	37%	17%	74%	0.4	243 g	294 g sec	1.21

The above data show that the oven-finished French fries according to the present invention (A) have technical attributes that are very similar to deep-fried French fries (C) that are considered the "gold

standard." The commercial oven-finished French fries (B) fall outside the desired ranges for surface Aw and the textural parameters (maximum force, area, and ratio of area to maximum force).

The above French fry products are also evaluated for flavor and texture by sensory testing. A panel of ~40 trained individuals rate the products for various sensory attributes on a scale of 1 to 9. Two sensory tests are run, evaluating each of the oven fry products directly against the deep-fried French fries. Following are the sensory test results; each numerical value is the average rating for that attribute.

Product	Sensory Test #1		Sensory Test #2	
	A	C	B	C
	Oven Fry- Present Invention	Deep-Fry- Gold Standard	Oven Fry- Commercial	Deep Fry- Gold Standard
Base Size	40	40	33	33
Potato Flavor	5.2	5.5	5.1 ^A	6.3 ^B
Fried Food Flavor	5.6	5.3	4.3 ^A	5.3 ^B
Off-Flavor	1.5	1.5	3.7 ^A	1.4 ^B
Surface Crispness	5.5	5.7	2.7 ^A	5.8 ^B
Interior Moistness	5.5	5.2	5.7	5.6
Overall Acceptability	6.0	6.6	3.3 ^A	7.0 ^B

Note: Within each sensory test, attribute ratings with letter superscripts are significantly different at a 95% confidence level.

The sensory test results reveal that the oven-finished French fries according to the present invention (A) have flavor and textural attributes very similar to the deep-fried French fries (C). In particular, the oven-finished French fries according to the present invention possess the desired textural dichotomy, i.e., a moist interior and a crisp crust, that is typically associated with deep-fried French fries. In contrast, the commercial oven fries (B) do not possess the desired textural dichotomy as revealed by a significantly lower surface crispness rating.

Example 2

Two oven-finished French fry products and one deep-fried French fry product are prepared as follows:

D. Oven-finished French fries according to the present invention:

The frozen shoestring-cut par-fried potato strips used as the starting par-fry in Example 1A are an acceptable starting product for this example (Simplot Par-Fries; J. R. Simplot Co.; Caldwell, ID). The par-fried potato strips have a moisture content of about 64% and a fat content of about 6%.

About 1 lb. of the frozen par-fried potato strips are further processed by deep frying in a 45 lb. oil capacity foodservice frying kettle 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 20 seconds. The moisture content of the resulting par-fry is about 48% and the fat content is about 14%. The frozen par-fries are packaged into foil-laminate bags and stored at about 0°F (-18°C).

The frozen par-fries are baked in a double impingement oven (Wolverine Corporation, Merrimac, MA; Model 2.0 x 051 pilot plant Jetzone™ oven) equipped with a continuous conveyor. The par-fries are arranged in a single layer on an open wire mesh tray that is placed on the oven conveyor belt. Hot air impinges on the product from both the top and bottom, delivered from two banks of tubes located above and below the conveyor belt. The air velocity measured at the product bed is about 5,500 feet per minute (1,676 meters per minute). The air temperature within the oven chamber is 450°F (232°C) and the conveyor speed is adjusted such that the residence time in the oven is 1.25 minutes. Immediately after exiting the oven, the fries are lightly sprayed with warm (~150°F) conditioned Primex 108 vegetable oil; about 3% oil by weight of the fries is sprayed onto the surface. The oven-finished fries are then immediately evaluated for various technical attributes or are salted and evaluated for flavor and texture by tasting.

E. Commercial oven-finished French fries:

Frozen samples of the Ore-Ida® Vend Fry® for use in the Ore-Ida French Fry Vendor™ (shoestring-cut; Ore-Ida Foods, Inc., Boise, ID) are obtained from a local distributor and stored at 0°F (-18°C) or lower. The frozen Ore-Ida® Vend fries are loaded into the freezer compartment of an Ore-Ida Model 890 French Fry Vendor™ vending machine (Crane National Vendors, Division of Unidynamics Corp., Bridgeton, MO). The Vend fries are baked in the French Fry Vendor™ according to the manufacturer's recommendations: about 3.5 oz. of frozen Vend fries are deposited into a rotating basket and then baked for about 40 seconds with forced hot air at 465°F (240°C) blowing through the basket. Upon completion of the baking cycle, the oven-finished fries are automatically dispensed and then immediately evaluated for various technical attributes or are salted, and evaluated for flavor and texture by tasting.

F. Deep-fried French fries (McDonald's™ French fries: "gold standard"):

The frozen shoestring-cut par-fried potato strips used as the starting par-fry for preparation of product "D" of this example (Simplot Par-fries; J.R. Simplot Co.; Caldwell, ID) are further processed by deep-frying. The par-fried potato strips have a moisture content of about 64% and a fat content of about 6%.

About 1.5 lb. of the frozen par-fried potato strips are allowed to thaw for about 1 hour at room temperature (70°F; 21.1°C) and then are deep-fried in a 45 lb. foodservice frying kettle containing

conditioned Primex 108 vegetable oil (blend of partially hydrogenated soybean oil and corn oil available from the Procter & Gamble Co.) for about 3 minutes at an oil temperature of about 335°F (168°C). Upon removal from the fryer, the deep-fried French fries are immediately evaluated for various technical attributes or are salted and evaluated for flavor and texture by tasting.

The above French fry products (D, E and F) are evaluated for bulk moisture, total fat, internal moisture content, surface Aw and Texture Value. The results are shown in the following table:

Product		Bulk Moisture	Total Fat	Internal Moisture	Surface Aw	Max. Force	Area	Ratio Area to Max. Force
D	Oven Fry-Present Invention	42%	15%	73%	0.3	276 g	324 g sec	1.17
E	Oven Fry-Commercial	50%	11%	72%	0.6	191 g	185 g sec	0.97
F	Deep Fry-Gold Standard	39%	16%	76%	0.4	266 g	335 g sec	1.26

The above data show that the oven-finished French fries according to the present invention (D) have technical attributes that are very similar to deep-fried French fries (F) that are considered the "gold standard." The commercial oven-finished French fries (E) fall outside the desired ranges for surface Aw and the textural parameters (maximum force, area, and ratio of area to maximum force).

The above French fry products are also evaluated for flavor and texture by tasting. The oven-finished French fries according to the present invention (D) have a flavor and texture similar to the "gold standard" deep-fried French fries (F). In particular, the oven-finished French fries of the present invention possess the desired textural dichotomy, i.e., a moist interior and a crisp crust, that is typically associated with deep-fried French fries. In contrast, the commercial oven fries (E) lack sufficient crispness and do not possess the desired textural dichotomy.

Example 3

A non-digestible fat composition is used to prepare the par-fried potato strips in the following example. The non-digestible fat composition is Olean™, from the Procter & Gamble Company, which comprises a blend of liquid and solid sucrose polyester. Sorted and graded Russet Burbank potatoes are peeled, washed, trimmed and cut axially into shoestring strips (0.25 inch square cross-section). The potato strips are blanched in hot water or steam and partially dried with hot air such that the potato strips are reduced in weight by about 15%. The partially dried strips are then par-fried in Olean™ for about 60 seconds at an oil temperature of about 375°F (190.5°C). The par-fried potato strips are then cooled and frozen in a blast freezer at -30°F (-34.4°C) and packaged. The par-fried potato strips have a moisture content of about 64% and a fat content of about 8%.

About 1 lb. of the packaged frozen par-fried potato strips are further processed by frying in a 45 lb. oil capacity foodservice frying kettle containing Olean™ for about 3 minutes at a temperature of about 300°F (149°C). The resulting par-fried potato strips are immediately frozen by immersion in liquid nitrogen for 20 seconds, packaged in foil laminate bags, and stored at normal freezer temperatures of approximately 0°F (-17.8°C). The par-fried potato strips have about 46% moisture and about 20% fat.

About 128 grams of the frozen par-fries are placed on an open wire mesh oven tray in a single layer and then baked at a temperature of about 400°F (204°C) in a forced air convection oven (Wells Manufacturing Co., Model No. M42003S) for about 2.5 minutes. A turbulent air flow exists within the oven chamber, with an air velocity at the center of the oven chamber just above the product bed of about 900 feet per minute (274 meters per minute). The fries are then transferred to an open wire mesh basket in a single layer and the basket placed within the treatment zone of a high velocity impingement oven (manufactured by Industrial Combustion Services, Inc., Tyrone, GA). Hot air at 375°F is directed onto the surface of the fries at a velocity of about 5,000 feet per minute (1,524 meters per minute). The fries are held in the impingement oven for 15 seconds.

The resulting reduced calorie oven finished French fries have a texture and flavor very similar to gold standard deep-fried French fries. The finished fries have a bulk moisture content of about 35%, a total fat content of about 15%, an internal moisture content of about 72%, a surface Aw of about 0.4, and a Texture Value of about 250.

Example 4

The frozen shoestring-cut par-fried potato strips used as the starting par-fry in Example 1A are an acceptable starting product for this example (Simplot Par-Fries; J. R. Simplot Co.; Caldwell, ID). The par-fried potato strips have a moisture content of about 64% and a fat content of about 6%.

About 1 lb. of the frozen par-fried potato strips are further processed by frying in a 45 lb. oil capacity foodservice frying kettle 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 335°F (168.3°C). The resulting par-fries are immediately frozen by immersion in liquid nitrogen for 20 seconds, and then equilibrated to about 0°F (-17.8°C). The par-fries have about 38% moisture and about 17% fat. The frozen par-fries are then surface hydrated by spraying a fine mist of water at -70°F (21.1°C) onto the surface of the par-fries. During the hydration process, the frozen par-fries are tumbled in order to achieve a uniform application of water onto the surface of the par-fries. Spraying of the water mist is continued until about 7% (by weight of the par-fries) of water is applied to the surface of the par-fries. The frozen hydrated par-fries are then stored at between 0°F (-17.8°C) and 20°F (-6.7°C). The hydrated par-fries comprise about 43% bulk moisture and about 15% total fat. Hydration of the par-fry surface increases the Aw of the crust region, thereby reducing or eliminating the Aw differential between

the internal core and the crust region, which is the driving force for moisture migration during frozen storage.

About 128 grams of the frozen, hydrated par-fries are prepared for consumption by baking in a forced air convection oven (Wells Manufacturing Co.; Model No. M42003S). The hydrated par-fries are arranged in a single layer on an open wire mesh oven tray and baked for 1.5 minutes at an air temperature of about 425°F (218.3°C). A turbulent hot air flow exists within the oven chamber. The air velocity at the center of the oven chamber (immediately above the product bed) is about 900 feet per minute (274 meters per minute). The oven-finished French fries have a desirable textural dichotomy, i.e., a crisp surface texture and moist interior. The finished fries have a bulk moisture content of about 39%, a total fat content of about 16%, an internal moisture content of about 72%, a surface A_w of about 0.4, and a Texture Value of about 290 (maximum force = 237 grams; area = 289 gram sec; ratio of area to maximum force = 1.22).

What is claimed is:

1. Oven-finished French fried potato product comprising:
 - a) from 32% to 50% bulk moisture;
 - b) from 8% to 25% total fat; and
 - c) a Texture Value of at least 200; wherein said Texture Value is the maximum force (grams) or the area (gram sec) under the force deformation curve during the first one-third of a compression test.
2. The product of Claim 1 wherein said oven-finished fries have a bulk moisture of from 33% to 44%, a total fat of from 13% to 23% and a Texture Value of from 210 to 1,000.
3. The product of Claim 1 or 2 wherein said oven-finished French fries have a surface water activity of less than or equal to 0.55 and an internal moisture of from 55% to 80%.
4. The product of Claim 3 wherein said oven-finished French fries are shoestring-cut fries.
5. The product of Claim 1, 2, 3 or 4 having a surface heat transfer coefficient at oven temperatures of from 50 to 400 watts/m²°C.
6. The product of Claim 1, 2, 3 or 4 having thermal conductivity of the crust region at oven temperatures of from 0.1 to 0.3 watts/m°C.
7. A product according to Claim 1, 2, 3, 4, 5 or 6 having a thermal conductivity of the inner core of from 0.4 to 0.7 watts/m°C.
8. A product according to Claim 7 wherein the ratio of the average area to average maximum force is at least 1.0 in the Texture Value Measurement.
9. A product according to Claim 8 wherein the surface Aw is less than or equal to 0.55.



* C L M S *



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(54) Title: OVEN-BAKED FRENCH FRIES HAVING DEEP-FRIED TASTE AND TEXTURE ✓ (57) Abstract The present invention relates to French fried potatoes produced from an oven that approximate the attributes and characteristics of French fries that have been finished by deep fat frying. The oven-finished French fries of the present invention can be differentiated from commercial and prior-art oven fries in that they possess a combination of attributes, in particular, bulk moisture, total fat, internal moisture, surface water activity and a Texture Value, that renders them virtually indistinguishable from deep fried French fries. The oven-finished French fries comprise from about 32 % to about 50 % bulk moisture, from about 8 % to about 25 % total fat, from about 55 % to about 80 % internal moisture content, a surface water activity of less than or equal to about 0.55, and a Texture Value (maximum force [grams] or area under the force deformation curve [gram sec] within the first one-third of a specific compression test) of at least about 200.		