

Coating for a potato product for finish-frying, a potato product provided therewith and method therefor

The present invention relates to a coating for a potato product for deep-frying, such as a
5 coating for french fries.

Potato products for finish-frying, particularly french fries for conventional deep-frying, are produced and consumed in large quantities worldwide. These products are usually rich in (available) carbohydrates and also high-calory, i.e. have a high energetic value. Certainly when large quantities are consumed, this can contribute toward an unhealthy lifestyle of a consumer,
10 which can result in medical and other problems.

Conventional coatings of potato products for finish-frying are usually aimed at achieving a desired colour of the end product, particularly of the finish-fried french fries, maximizing shelf life after the frying process, particularly for so-called fast-food restaurants, and/or improving the (crust) crispness. The french fries are for this purpose usually finish-fried with oil in a deep-fryer.

15 The present invention has for its object to provide a coating for a potato product with which a potato product can be realized with a relatively low content of (available) carbohydrates, which is in addition also relatively low-calory relative to existing similar potato products, preferably has a limited fat content, and is perceived by the consumer as being a tasty product of good quality in respect of, among other qualities, crunchiness, bite, mouthfeel, colour, flavour and
20 the like.

This object is achieved with the coating according to the present invention, wherein the coating comprises a composition for a low-calory potato product for finish-frying having by weight, relative to the weight of the composition:

- 30-60% modified starch comprising high-amylose starch;
- 25 - 20-30% flour;
- 5-20% dextrin;
- 2-10% unmodified starch; and
- 0.01-2% carbonate.

The composition for the coating is subsequently applied as suspension to a processed
30 potato product by dipping, spraying, atomizing or other suitable manner of applying the coating, wherein it is adhered to or on the potato product with a deep-frying step (pre-frying). The specific composition according to the invention interacts with the product and forms there a protective layer, resulting in the most optimal possible end product after the performing of further processing steps, including deep-freezing and finish-frying. Deep-freezing can be performed in accordance
35 with diverse time-temperature relations. French fries can alternatively be finish-fried without being

deep-frozen. According to the invention an intermediate product is therefore provided with the coating according to the invention so as to thereby improve the final end product for the consumer.

Such a specific approach, wherein the coating according to the invention is applied to an already processed product on which further final processing is performed, including
5 finish-frying with for instance hot air (air frying) or optionally conventional deep-frying making use of oil. The finish-frying, preferably with hot air, is usually preceded by deep-freezing and transporting of the product. This requires a good interaction between the individual components of the composition. This is achieved with the specific composition according to the invention.

The modified starch according to the composition, for instance from potato, corn and/or
10 tapioca, provides for a desired hardness and crispness of the crust of the potato product to which the coating is applied. The modified starch content is in addition important for adhesion of the coating to the potato product and the transparency of the coating, so that it acquires the desired whitish yellow to golden yellow colour during processing, whereby it remains attractive for consumption. The modified starch comprises high-amylose starch. This high-amylose starch is a
15 starch with at least a content of about 60% amylose. It has been found that in a currently preferred embodiment according to the invention a quantity of modified starch in the range of 30-50% yields particularly good results for the end product with a dextrin content preferably in the range of 5-20%.

In addition to being a filler, the quantity of flour also has a positive effect on the adhesion
20 and the crispness, so that the effect of the modified starch is hereby further enhanced in respect of these aspects. The flour is for instance derived from rice and/or corn. It is found here that particularly flour from rice enhances the stated effects.

The unmodified starch, for instance from corn, has in addition to an adhesive action also a stabilizing effect, and a so-called 'gelling' effect for the coating. It has been found that the ratio of
25 modified starch and unmodified starch is of great importance here for the final result of the potato product after the finish-frying process. This result relates to, among other factors, the extent to which the interior, or filling, of the potato product is cooked and its texture and structure, the crispness/crunchiness of particularly the crust of the potato product, and the desired golden yellow colour of the finish-fried end product. The relation between crispness of the crust and the soft
30 texture/structure of the filling is relevant here.

The specific coating composition according to the invention has been found particularly suitable for use with potato varieties with a low energetic value as starting material for the potato product. Such low-carbohydrate (and thereby low-calory) potatoes, including the potato varieties Colomba and Carrera, can be characterized by a low underwater weight for instance equal to or
35 lower than 300 g/5 kg (corresponding to 16.8% dry substance and a specific weight of 1.063). In the context of the description of the invention carbohydrates are specifically understood to mean

available carbohydrates, also referred to as digestible carbohydrates, which contribute toward the calorific values via the digestive system.

Said potato varieties are usually used in current practice for mash pots, mashed potato and boiling and frying processes other than deep-frying. Deep-frying of potato products from these potato varieties results in a conventional frying process to a very considerable brown discoloration, loss of flavour and increase in calorific value. It has been found that the coating in accordance with the composition according to the invention is extremely suitable for particularly these preferably low-carbohydrate and low-calory potato varieties with low underwater weight (in particular equal to or lower than 300 g/5 kg) and results in an end product, particularly french fries and optionally also other potato products, with the desired properties in respect of crispness, hardness, extent to which it is cooked, colour and the like. By using low-calory and preferably low-carbohydrate potato varieties in interaction with the coating with the composition according to the invention, whereby absorption of (deep-frying) oil is for instance counteracted, the end product is also relatively low-calory and low-carbohydrate. It is found that, by applying the coating with the composition according to the invention, a reduction in energetic value (in kCal) of more than 20%, even more than 25% and up to more than 30%, and under certain conditions even about 50%, is possible compared to french fries as currently prepared by known fast-food restaurants. This means a significant reduction in energetic value of the end product.

A further effect of the coating composition according to the invention is the significant reduction in the quantity of carbohydrates in the end product. Conventional french fries as prepared in fast-food restaurants typically have a content of about 40% by weight of carbohydrates. The end product with the coating of the composition according to the invention has a lower carbohydrate content. An end product of a low-calory potato provided with the coating according to the invention thus has a content of less than 35%, even less than 30% and even as much as less than 25%. This means a significant reduction in carbohydrate content of the end product. It is also found that a reduction in fat content can be realized.

The realized reduction in calories and the reduction in the quantity of carbohydrates, as well as fat, result in a healthier end product, whereby an adverse effect which conventional french fries can have on a consumer is counteracted or can even be wholly obviated. This will of course also depend on the fitness and lifestyle of the consumer. The reduction in calories and the quantity of carbohydrates does however make the final end product, such as french fries, considerably healthier, whereby consumption no longer results in the great (medical) problems as associated with the excessive consumption of conventional products as currently available at fast-food restaurants.

It has been found that the end product obtained with the coating according to the invention is perceived to be a good quality product in respect of, among other qualities, crunchiness, bite,

crispness, mouthfeel, colour, flavour, and the like. Experiments and measurements also demonstrate that a good quality product is obtained with the coating according to the invention. A further additional advantage of the end products obtained with the coating of the composition according to the present invention is that they also become more readily suitable for a larger group of consumers with diverse diets or dietary requirements.

It has been found particularly that the use of the coating in the composition according to the invention, preferably with potatoes of said varieties, results in a lower-calory potato product according to claim 15.

The modified starch preferably comprises chemically acetylated starch, wherein the chemically acetylated starch preferably comprises 10-25% of the total content of modified starch. The content of phosphorylated starch amounts to 75-90% of the modified starch. It has been found that herewith, and in particular the stated mixing ratio, the above stated effects are further enhanced. A possible supplied product for this modified starch is Crisp Film. In the currently preferred embodiment the dextrin also comes from a supplied product Crystal Tex 644, in this embodiment from tapioca. In another embodiment potato is the source. The above stated effects are hereby enhanced still further, particularly in combination with said modified starch, preferably a combination of potato starch and corn starch and/or tapioca. The unmodified, preferably high-amylose starch preferably comes from corn. It has been found that said combination of raw materials provides the enumerated properties.

In an advantageous preferred embodiment according to the present invention the composition further comprises a percentage by weight of 0.01-1% of thickener, preferably a percentage by weight of 0.01-0.5%.

The thickener increases the stability of the coating, particularly during the further treatment process. This is particularly relevant when the coating is applied to a pre-processed product which still has to undergo diverse finishing processes, as is particularly the case with french fries. Using the thickener the effect of the coating according to the invention is therefore preserved during the further treatment processes.

The thickener preferably comprises xanthan. It has been found that xanthan works particularly effectively and makes a significant contribution toward the stability of the coating, particularly during the treatment process.

5 In a further preferred embodiment according to the present invention the percentage by weight of bicarbonate, for instance potassium bicarbonate and/or sodium bicarbonate, lies in the range of 0.01-1%, preferably in the range of 0.01-0.5% and most preferably in the range of 0.01-0.1%.

10 The crispness of the outer side of the end product is further improved by providing a carbonate, preferably added as component of baking powder. A percentage in the range of 0.01-0.1% has been found particularly advantageous here in combination with the other components of the composition according to the invention. When sodium bicarbonate is used in said range (including sodium) there is over 70% effective bicarbonate substance.

In a further advantageous preferred embodiment according to the present invention the coating composition comprises a percentage by weight of 5-10% of mineral salts.

15 The flavour of the end product and the ionizing effect of the coating are improved by adding mineral salts, in a currently preferred embodiment NaCl and/or KCl. It has even been found possible here to substantially dispense with additional additives to the end product, including salt. The amount of mineral salt in the end product can hereby be precisely adapted to the coating of the composition according to the invention, without further additives to the end product being
20 required. This simplifies the treatment process as well as the process of serving the prepared french fries in a fast-food restaurant, since fewer operations need be performed. In addition, the coating according to the present invention avoids too large a quantity of salt being added after the finish-frying process, so that possible adverse consequences thereof are avoided.

25 In a currently preferred embodiment it is possible, as a result of the coating according to the composition of the invention, to dispense with later addition of salt. In addition to the above stated (production) advantages, this minimizes the intake of salt by a consumer. The flavour of the product is such here that it is perceived by the consumer as being of good quality and not needing additional salt. In an advantageous embodiment of the coating according to the invention it has been found that the salt perception experienced by the consumer is such that no need is felt to later
30 add additional salt, with for instance the risk of overdosing. It has been found that, with the coating according to the invention, the salt intake by the consumer can be reduced to about 25%, or even to about 50%, of conventional further salted french fries in a fast-food restaurant.

35 It has also been found that the coating composition according to the invention can be modified to properties of the starting material, whereby aspects such as origin, storage life and/or storage conditions no longer have a significant influence on the final end product, for instance the french fries, or at least the influence of these aspects can be reduced. It is also possible to make

allowance for a difference in seasonal and regional variables during the whole (growth) cycle in the growing process between the different locations in different countries. The ratio of the modified and unmodified starch can for instance thus be varied, preferably within the above stated limits, in order to thereby realize a quality of the obtained end product which is more consistent over time.

A further problem with existing products is that they can have a relatively (too) high acrylamide content. Although there is still insufficient clarity/evidence as to whether, and the possible extent to which, a high acrylamide content could be harmful to human health, there is a consensus to keep the acrylamide content as low as possible.

The composition of the coating in any of the embodiments already described above is found to be particularly successful in providing a potato product with a relatively low acrylamide content compared to conventional potato products, particularly deep-fried french fries.

Applying the coating according to the invention, preferably in combination with a preferred finish-frying method with an air fryer, achieves that the acrylamide content of the end product, the finish-fried french fries, is considerably reduced compared to the conventional products. Possible risks to consumers in respect of the acrylamide content are hereby reduced. It has been found that a significant reduction in acrylamide content is realized with the coating of the composition according to the invention.

The present invention also relates to a (finish-friable) potato product provided with a coating composition as described above.

Such a potato product provides the same effects and advantages as described for the coating. A potato product according to the invention comprises, among other products, finish-friable french fries as deep-frozen product, as well as french fries which can be finish-fried immediately. The coating can also be applied to other potato products according to the invention.

In an advantageous embodiment according to the invention the coating is applied in percentage by weight of the coating composition relative to the total weight of the end product in the range of 5-18%, preferably 5-16%, more preferably 10-15%, still more preferably 11-15%, and most preferably 12-14%.

It has been found that the above desired effects are achieved as optimally as possible by applying a coating composition according to the invention in said range, and particularly in the range of 12-14%.

The coating is preferably applied to the potato product in a coating process. The coating is brought here into a solution/suspension with a temperature usually in the range of 5-25°C. This is usually referred to as the batter. With the coating according to the invention the dry substance content preferably lies in the range of 30-55%, preferably in the range of 35-45%. The absorption by the product, referred to as the pick-up, preferably lies in the range of 9-18% of the coating

suspension (batter), preferably in the range of 10-16%. It has been found here that the ratio of pick-up and dry substance influences colour, kCal, crispness and other qualities. It has thus been found that good results are provided with a pick-up in the range of 15-16% and dry substance of about 30%. Per one percent less pick-up about 2.5% more dry substance is required, up to about 45% dry substance at a pick-up to 10%, in order to thus realize a good result.

Providing the potato product with a coating according to the invention achieves that starting material, i.e. the potato as raw material for the potato product, with a relatively low underwater weight can be used. It is known in practice that potatoes with a low underwater weight are difficult or impossible to finish-fry in view of the resulting brown discoloration which occurs during the frying process and the poor limp structure obtained. Such potatoes are usually applied at the moment for for instance mash pots and typically have underwater weight equal to or lower than 300 g/5 kg. By applying the coating according to the invention to such potato varieties with such a low underwater weight an end product is obtained with a low energetic value, a low carbohydrate content and a low acrylamide content, with a reduced salt intake.

Examples of potato varieties which, when provided with a coating according to the present invention, result in the potato product according to the invention are the Colomba, Carrera and Evora with an underwater weight lower than 300 g/5 kg. It will be apparent that use of other potato varieties with a low underwater weight is in principle also possible as starting material for the potato product according to the invention. It has however been found that the stated potato varieties provide a potato product which is relatively low-calory and in addition has a relatively low carbohydrate content and fat content without undesirable brown discoloration occurring during the frying process. The health of consumers is hereby enhanced, or at least not adversely affected, when the potato products are consumed. Owing to a low carbohydrate content, and given that the product is relatively low-calory, the potato product according to the invention in addition becomes suitable for a number of specific diets, whereby a larger group of consumer products is made available to a group of consumers who (have to) follow such a diet. It is also found that a good texture of the end product, which in addition is also more uniform, can be obtained with the coating according to the invention. The texture is for instance characterized here on the basis of a breaking test, wherein the force exerted on an end product at which the product breaks is determined. It is found that by providing a potato product, particularly of a variety with a low underwater weight, with the coating according to the invention a uniform breaking value is obtained in the range of 1.5-3.5, preferably 1.5-2.5 Newton. Conventional french fries display clearly greater variation in this aspect. The coating can be applied in similar manner to potatoes of other varieties, in particular Evora.

The invention further also relates to a method for preparing a potato product, wherein the method according to the invention comprises of:

- providing a potato product from a starting material; and
- applying a coating as described above to the potato product.

The method provides the same advantages and effects as described above for the coating and/or the potato product.

5 The successive steps in the preparation process are more particularly: peeling > cutting of french fries > washing > optionally selecting products > washing > blanching > drying > coating > blast freezing > storage at -20°C > finish-frying.

 The starting material is the harvested potato, preferably of a variety with a low carbohydrate content, preferably the varieties Colomba and Carrera. It has been found that these
10 varieties result in an end product, in particular finish-fried french fries, having a low carbohydrate content and in addition being low in calories.

 In a currently preferred embodiment the basic product is washed, preferably peeled, cut, blanched or cooked at about 75-80°C for about 10 minutes and dried in order to remove adhering water and to optimize adhesion of the coating, after which the product is provided with the coating
15 using a bath and/or sprayers, and in the coating process is subsequently pre-fried in or with an oil at about 150°-170°C. The coating is preferably applied with a suspension provided with a dry substance content in the range of 30-55%, preferably in the range of 35-45%. The potato product provided with coating can as desired then be deep-frozen or immediately finish-fried in a finish-frying process.

20 The finish-frying is preferably performed using a so-called air fryer. It has been found that performing the frying process in such an air fryer has a positive effect on the structure of the final french fries, while no further absorption of (deep-frying) oil by the potato product will in principle take place.

 In a particularly advantageous preferred embodiment according to the invention the
25 method comprises the step of modifying the coating composition on the basis of the origin of the potato product, storage life and/or storage conditions.

 Modifying the coating composition on the basis of said parameters and/or optional other parameters, including among others the potato variety, achieves that a quality/uniformity of the end product is obtained which is more consistent over time. This enhances the identity and
30 reproducibility of the end product, which thereby acquires as it were a kind of identity of its own for the producer.

 In a particularly advantageous preferred embodiment according to the invention the method further comprises the step of selecting a batch for the purpose of providing a lower-calory potato product for finish-frying, comprising of determining the dry substance content for a batch as
35 a function of frying time.

It has been found surprisingly that the dry substance content as a function of the frying time has a predictive value for the dry substance content of coated low-calory french fries. Particularly the directional coefficient of the curve of the dry substance content in relation to the frying time can be used here as suitable parameter for the selection of batches. Surprisingly, the initial dry substance content of the raw product strips is not predictive. With said test according to the invention it is possible to select batches prior to processing by determining the dry substance content as a function of frying time. This avoids an unsuitable batch being processed, which would result in product loss. This therefore further increases the effectiveness of the production process. This will be further elucidated in the discussion of several experiments. It is optionally also possible to adapt process conditions to the respective selected batch. The obtained quality of the end product can hereby be further improved.

It has surprisingly been further found that the dry substance content as a function of the frying time, and more particularly the directional coefficient of the curve of the dry substance content relative to the frying time, likewise has a predictive value for the dry substance content of finish-fried french fries provided with the coating according to the invention. This further increases the reliability of the selection of batches for processing to finish-friable and/or finish-fried low-calory potato product.

In the assessment of a batch for suitability a value for said directional coefficient is preferably assessed according to the invention during determination of the relation between dry substance content and frying time. A value hereof in the range of 4-6 with as unit the percentage of dry substance per minute of frying time (grams of water per minute) at a temperature of 180°C is employed here in order to evaluate whether a batch is suitable for processing.

Further advantages, features and details of the invention are elucidated on the basis of preferred embodiments thereof wherein reference is made to the accompanying drawings, in which:

- Figure 1 shows an overview of the process of preparing a potato product; and
- Figures 2A-B show views of products with and without the coating according to the invention.

In the treatment process 2 (figure 1) following harvesting 4 of the potatoes, the potatoes, following optional selection 6, are optionally stored 8 in a storage location under the best possible storage conditions so as to avoid formation of sugar as far as possible during storage. Once the potatoes have been delivered to the production location, they are preferably selected 10, washed 12 and usually peeled 14. After peeling, the potatoes are cut 16 into the desired form or otherwise brought into a desired form. After the cutting process there usually follows a blanching process 18 at a temperature of for instance about 80°C. The product is dried and preferably blown dry, wherein excess water is removed from the product and the product is made suitable for optimal

adhesion of the coating. After an optional pre-dusting step 20, which is omitted in a currently preferred embodiment, the potato products are provided with the desired coating 22 in a coater using for instance a bath and/or sprayers, and then pre-fried 24. After application of the coating and the pre-frying, the potato products are optionally frozen 26 to form a deep-frozen product or optionally refrigerated and can be finish-fried 28 at a later stage. It is also possible to finish-fry the products immediately in a finish-frying process, preferably by making use of air frying, wherein the finish-frying is performed with hot air. During application of the coating the composition can optionally be varied to some extent depending on product information about the starting material.

Some experimental results will be discussed below wherein french fries produced with the coating according to the invention are compared to conventional french fries from a fast-food restaurant.

The conventional values for so-called small french fries are given per 100 grams in Table 1.

Table 1: Conventional Small French Fries (per 100 g)

Calories (kCal)	307
Carbohydrates (g)	40

Oven fries have an energetic value per 100 grams of about 302 kCal and a carbohydrate content of about 46 grams.

In the context of the invention the necessary experiments have been performed according to process 2 with a low-calory potato, such as the Colomba, which is deep-fried (fresh) in usual manner, i.e. without being deep-frozen, and in a first experiment is not provided with a coating.

The potato is peeled, cut to cut size 10 x 10 mm and blanched at 80°C for 10 minutes. The product is then pre-fried in oil for about 2-4 minutes at about 145°C and finish-fried in oil for about 3 minutes at 180°C. It will be apparent that variations in said times and temperatures are possible according to the invention, for instance blanching at said relatively high temperature for said period of time. Times and conditions applied depend on, among other factors, product, skills and preferences. The end product resulting from the experiment is shown in figure 2A, which clearly shows that a very considerable brown discoloration has occurred.

In addition to said brown discoloration in the finish-frying process, the measurements on the end product without coating of the potato variety Colomba show a (very) high acrylamide content of far above 1000 µg/kg. An increase in the energetic value to far above 200 kCal/100 g is obtained due to absorption of fat/oil, while the amount of carbohydrates is relatively low as a result of the use of potatoes of the Colomba variety.

An experiment was subsequently performed wherein the coating as described above was applied and an analysis was performed on the intermediate product. The coating according to the invention as used in experiments comprises for instance about 45% modified starch, with

additionally about 15% dextrin (tapioca), 7.5% unmodified starch, 25% flour, 0.1% bicarbonate, about 7.5% mineral salt (in particular sodium chloride) and for the rest small parts of thickener and other components. The obtained product shows a low energetic value and a relatively high moisture content. In this experiment a drying step is performed. Drying temperature is preferably about 60-90°C. In the case of the coating use is preferably made here of a pre-frying time of about 2 minutes at about 160°C. Excess coating is removed in a blowing-off step (and optionally reused).

The intermediate product is then deep-frozen and then finish-fried, wherein water will evaporate and so there will be more solid substance per 100 g, resulting in an increase in the energetic value relative to the analysis prior to the finish-frying process. A finish-frying process is performed in an air fryer for about 7-8 minutes at a temperature of about 180°C. In this and subsequent experiments use is made in the relevant cases of a Philips "Air fryer". The analysis of the end product, for a cut size of 10 x 10 mm, is shown in Table 2.

Table 2: Analysis of end product with coating (per 100 g, 8 samples of potato variety Colomba)

Analysis	Unit	Result
Protein (Kjeldahl, f=6.25)	% (m/m)	2.2-2.9
Energetic value (kCal)	kCal/100 g	149-171
Energetic value (kJ)	kJ/100 g	626-716
Tot. available carbohydrates	%(m/m)	21.4-23.9
Fat total (Soxhlet)	% (m/m)	5.2-6.5
Moisture (Karl Fischer)	% (m/m)	61.7-66.2
Dietary fibre AOAC 985.29	% (m/m)	4.3-6.7
Acrylamide	µg/kg	<50

The end product shows a significant reduction in energy content compared to conventional french fries and a great reduction in content of available carbohydrates (measurement Campden BRI, UK). The content of fat and acrylamide is in addition considerably lower than in conventional french fries.

The Carrera variety likewise has a relatively low energetic value, with measurements for the energetic value in the range of 141-176 kCal/100 g, while in a similar determination this is higher for a potato variety conventionally used for french fries, such as Innovator, for instance in the range of 216-229 or even for instance in the range of 216-250 kCal/100 g.

Energetic values realized with the method according to the invention are about 60 kCal/100 g after blanching, about 110 g kCal/100 g for the pre-fried french fries provided with coating, and about 150-170 kCal/100 g after finish-frying. It will be apparent that such values can depend on, among other factors, aspects such as a cut size of the product and other process and

preparation parameters.

When the coating according to the invention is used in combination with a so-called air frying process, the energetic value per 100 g amounts to about 150-170 kCal, and even lower, and the carbohydrate content to about 21-24% by weight. An enormous reduction in acrylamide is also realized, to clearly below 100 µg/kg. An end product is shown in figure 2B. French fries are hereby obtained with a low energetic value and with a low carbohydrate, acrylamide and fat content.

The end product according to the invention has also been compared to conventional french fries in respect of salt content. Conventional french fries in a fast-food restaurant are further salted, resulting in a sodium content of about 0.4-0.8%. This is not yet a case of the salt overdosing which occurs frequently in practice. The experiments with the coating according to the invention have shown that the consumer experiences a taste sensation in the end product such that further salting is unnecessary. The sodium content of the end product according to the invention lies markedly lower (for instance about 0.09-0.14 gram of sodium per 100 grams of non-fried french fries, depending on, among other factors, batter concentration and pick-up). Due to loss of moisture during the finish-frying step this corresponds to about 0.12-0.16% sodium on the end product according to the invention. This means a significant reduction in sodium intake by a consumer per regular portion of french fries.

The experiments show that the coating according to the invention surprisingly gives better results than conventional coatings. These better results relate particularly to a low-calory potato products for finish-frying with fewer calories than a conventional potato product. It has been found here that such a reduction in calories can be realized in diverse process conditions during the production process, in particular temperatures and treatment times, wherein specific conditions can improve the quality still further.

A number of experiments have also been performed, some results of which are further described below. These demonstrate the effect of the present invention.

Use was made in the experiments of batches of potato varieties with a dry substance content in the range of 14-17% dry substance for making low-calory potato products. Varieties used were Colomba, Carrera and Evora. Products obtained from the experiments were compared to standard potato products with usual calorific value by making use of batches of the potato variety Innovator with a dry substance content of 22-24%.

In the context of the experiment the successive steps in the preparation process were: peeling > cutting of fries > washing > selecting square strips > washing > blanching > drying > coating > blast freezing > storage -20°C > finish-frying.

The cut size applied amounted to about 10 x 10 mm, or for several experiments 12 x 12 mm. The blanching experiments were performed with a batch of potatoes of the Colomba and Carrera varieties with a dry substance content of < 16% on the basis of fresh weight as suitable

starting material for coated french fries with a calorific value according to the invention. Potatoes with a diameter of 40-70 mm and variable lengths were washed and manually peeled with a paring device prior to the experiments. French fries were cut and, after removal of edge strips, cut french fries had adhering starch removed in a washing step and were stored under water prior to the

5 further experiments. The production of the french fries was performed during all successive steps as a batch process beginning with 500 g of raw french fry strips. Washed french fry strips of both varieties were blanched in a fine-mesh nylon net bag in a water bath in accordance with a time series with incremental time (5, 7.5 and 10 minutes) and a temperature series with incremental temperature (72, 76, 80 and 84°C) in all possible combinations. The quality of cooking during the

10 blanching process for french fry strips can be determined by the extent to which starch is gelatinized by the heat treatment. This can be determined by breaking strips, pressing the two strip parts against each other at the original position and then slowly pulling them apart. In the case of properly blanched strips starch threads, which have their origin in gelatinized starch, will occur during pulling apart of the two strip parts. Shown in table 3 is the extent to which the french fry

15 strips are cooked at the different time-temperature combinations. The following table 3 shows that 10 x 10 mm strips of the Colomba and Carrera varieties are properly blanched with a correct degree of cooking in the case of the combinations 10 min-80°C and 7.5 min-84°C.

variety	time (min)	temperature in °C			
		72	76	80	84
Colomba	5	uncooked	almost	slightly	somewhat uncooked
	7.5	almost	slightly	somewhat uncooked	cooked
	10	slightly	somewhat uncooked	cooked	overcooked
Carrera	5	uncooked	almost	slightly	somewhat uncooked
	7.5	almost uncooked	slightly	somewhat uncooked	cooked
	10	slightly	somewhat uncooked	cooked	overcooked

20 Table 3: The extent to which the french fries are cooked as a function of different time-temperature treatments measured as the ability to form starch threads when broken strip parts are pulled apart. Explanatory notes on descriptions used for the extent of cooking: Uncooked: no starch thread; almost uncooked: slightly adhering strip parts, no starch thread; slightly uncooked: adhering strip parts, no starch threads; somewhat uncooked: adhering strip parts, several starch

25 threads; cooked: well adhering strip parts, many starch threads; overcooked: well adhering strip parts, many starch threads, soft tissue structure.

A second reason for blanching is to prevent discoloration of strips during the preparation process. Discoloration of strips as a consequence of enzymatic processes is visible as a red

discoloration, usually on the outer ends of the strips. The colour develops quickly after the treatment when the strips are exposed to air. Strips of the sample of the Colomba variety display red discoloration for most time-temperature combinations, with the exception of the combinations 10 min-80°C and 7.5 and 10 min-84°C. The strips from the Carrera sample display red discoloration for substantially all time-temperature combinations, with the exception of 10 min-80°C and 10 min-84°C. The deactivation of colour-forming enzymes by a heat treatment is apparently linked to variety and/or batch and takes place optimally in both batches in the case of the 10 min-80°C treatment in respect of both the extent to which the product is cooked and its colour. The blanching condition 10 min-80°C gives optimal results for substantially all potato samples as described in the examples of this patent. Results are included in the following table 4.

variety	time (min)	temperature in °C			
		72	76	80	84
Colomba	5	red discoloration	red discoloration	slight red discoloration	somewhat red discoloration
	7.5	red discoloration	slight red discoloration	somewhat red discoloration	no red discoloration
	10	slight red discoloration	somewhat red discoloration	No red	no red discoloration
Carrera	5	red discoloration	red discoloration	red discoloration	slight red discoloration
	7.5	red discoloration	red discoloration	slight red discoloration	somewhat red discoloration
	10	red discoloration	slight red discoloration	No red	no red discoloration

Table 4: The discoloration of french fry strips as a function of different time-temperature treatments measured as red discoloration of strips after the blanching treatment for 30 minutes exposure to air. Explanatory notes on colour descriptions used: red discoloration: intense red colour forming on >30% of the strip surface area; slightly red discoloration: red bloom on >30% of the strip surface area; somewhat red discoloration: red bloom on about 10% of the strip surface area; no red discoloration: surface free of red colour.

During the production process for low-calory french fries it is the object to produce french fries with a significantly lower calorific value on the basis of a lower dry substance content, and all process steps contribute toward realizing this objective. In the above described experiment the effect of blanching conditions around the optimum (10 min-76°C, 10 min-80°C) on the quality of the coating and finish-frying was studied after a drying step of 3 minutes in air on the basis of drying in their own heat following the blanching step. French fry strips of the Carrera variety with a dry substance content of 16.1% were prepared in this experiment as specified above and subsequently dried on a stainless steel drip grid in air for 3 minutes, after which they were free of adhering water and dry in appearance.

The blanched french fry strips were subsequently coated with Clearcoat LC N6K2 V2 (P150305) - 1 part powder / 1.75 parts water (36.4 % dry substance) with a formulation as specified in the present application on a Gaser coating line. The french fry strips were fully

immersed twice in the coating suspension during the coating process, after which excess coating was blown off by means of a blow nozzle above the conveyor belt in the direction of the oil bath of the deep-frying unit. French fry strips were coated in these conditions with 14% coating (pick-up 14%) on weight basis. The deep-frying unit used to apply the coating was a Frymaster (H17, 17 kW, PH117 CSD) with a volume of 25 l deep-frying oil. Coated strips of the whole batch drop from the conveyor belt within a period of 15 seconds into the oil bath of the deep fryer and are collected in a deep-frying mesh basket. In this example the coating was fried onto the french fry strips at an oil temperature of 160°C for a period of 1.5 and 2 minutes. Immediately after the deep-frying step the coated french fry strips were frozen for 8 minutes to a temperature of -5°C in a so-called chiller (Hobart blast chiller BCF21, 2350W). Following the blast freezing step the french fry strips were further stored in closed plastic bags in a freezer at -20°C for a minimum of 1 day prior to further preparation steps. Finish-frying preferably takes place in hot air equipment with high air circulation as in an air fryer. The frozen coated french fry strips in this example were finish-fried in portions of 250 g in the air fryer at a temperature of 180°C for a period of 7, 7.5 and 8 minutes. The effect of the various preparation steps in this example was assessed during the coating and finish-frying process on the basis of evolution of the dry substance content and the texture measured as breaking force during a three-point breaking test on the strips. Dry substance is a good relative indicator of the calorific value of the product. The breaking force of finish-fried strips as a measure of crispness of the crust of strips is measured in accordance with the standard TPA test of Stable Micro Systems (TXA texture analyzer) at a speed of 1 mm/s and a measurement period of 20 seconds. Fmax (in N) is the maximum force measured in the force-time curve. Fmax was measured on 10 strips per method and expressed as average. Fmax is a parameter for crispness and hardness of strips.

The influences of the different methods on the evolution of dry substance and texture of the coated, optionally finish-fried french fries are shown clearly in table 5.

The highest values were obtained in the combination 80°C blanching, 1.5 or 2 minutes coating/pre-frying and 8 minutes finish-frying. The optimum combination of preparation steps is determined by a combination of quality characteristics as detected in the prepared french fry strips. The exterior of french fry strips according to the applied methods is golden yellow with light brown colour on the edges and outer ends of the strips and in accordance with USDA standards (<USDA scale 2).

It can be concluded in summary that method 16 in table 5 results in low-calory french fry strips with the best balance between the desired characteristics. The crust of coated french fries of methods 1-16 is characterized by a grainy external structure and a lack of smoothness on the surface of the strips. It is expected that further improvements in the drying process in respect of drying time and drying temperature will result in a better adhesion and outflow of the coating

during the frying process, and in smoother crusts.

description	treatment				AirfryerDS%	? DS% rel. to raw	? DS% rel. to 0	texture Fmax (N)
	blanching 10 min at	frying coating °C minutes at 160	Finish-frying °C minutes at 180	°C				
raw strips					16.1			
method 1	76	1.5	0		25.2	9.1		
method 2	76	1.5	7		33.8	17.7	8.5	0.6
method 3	76	1.5	7.5		33.7	17.6	8.5	0.7
method 4	76	1.5	8		34.9	18.8	9.6	0.7
method 5	80	1.5	0		28.8	12.7		
method 6	80	1.5	7		39.3	23.2	10.5	1.0
method 7	80	1.5	7.5		40.8	24.7	12.0	0.9
method 8	80	1.5	8		41.9	25.8	13.1	0.8
method 9	76	2	0		27.4	11.3		
method 10	76	2	7		35.6	19.5	8.2	0.7
method 11	76	2	7.5		35.9	19.8	8.5	0.7
method 12	76	2	8		40.0	23.9	12.6	1.0
method 13	80	2	0		28.4	12.3		
method 14	80	2	7		38.8	22.7	10.4	0.8
method 15	80	2	7.5		39.3	23.2	10.9	1.1
method 16	80	2	8		38.8	22.7	10.4	1.1
average	76	1.5			34.1	18.0	8.9	0.7
average	76	2			37.2	21.1	9.8	0.8
average	80	1.5			40.6	24.5	11.9	0.9
average	80	2			39.0	22.9	10.6	1.0
average			0		27.5	11.4		
average			7		36.9	20.8	9.4	0.8
average			7.5		37.4	21.3	10.0	0.9
average			8		38.9	22.8	11.4	0.9

Table 5: The expression of dry substance and texture characteristics of french fry strips under the influence of applied blanching, coating and finish-frying steps. Characteristics are shown per method and as averages as stated.

Described below is the further optimization of the drying process which must result in smooth, non-grainy crust structures of coated french fry strips. Coated french fry strips were produced from a batch of Colomba potatoes with a dry substance content of 13.2% as according to the above described method with a blanching treatment of 10 min-80°C and subsequent drying with different drying times (3, 5, 7.5 and 10 minutes) at different temperatures (60, 70, 80°C) in a drying oven (Termaks TS9430).

The coated french fry strip samples as according to the various described treatments were subsequently assessed for the quality of the coating in accordance with external characteristics with focus on degree of covering, adhesion to the strips, smoothness and roughness and for dry substance content as a measure of calorific value. The coat characteristics of french fry strips were scored by sight as indicated in the key of table 6. Optimally coated strips must combine a good coverage and adhesion with a smooth structure. Adhesion and outflow of the coating during the

frying process is a condition for obtaining smooth coatings. The smoothness of coatings is a function of drying time and drying temperature, with the best result in the combination of a drying time of 10 minutes and a drying temperature of about 80°C.

Drying temperature °C	drying time minutes	coat covering area % covered	coat adhesion adhesion to surface	coat structure Smoothness coating
60	3	65	poor	very rough
60	5	75	poor - reasonable	rough
60	7.5	80	reasonable	rough
60	10	85	reasonable	rough
70	3	70	poor - reasonable	rough
70	5	80	reasonable	rough
70	7.5	85	reasonable	somewhat rough
70	10	90	reasonable - good	somewhat rough
80	3	75	poor - reasonable	rough
80	5	85	reasonable - good	somewhat rough
80	7.5	98	good	smooth
80	10	100	very good	very smooth

Table 6: Coat covering, coat adhesion and coat structure of french fry strips as a function of drying temperature and drying time prior to the coating process. Characteristics are scored visually according to the following scales: Coat covering as % covering of the strips, adhesion of the coat on a category scale from poor to very good, coat structure on a category scale from very rough to very smooth.

The application of a drying step to optimize the coating process is a preferred step which could affect the dry substance and calorific value of the french fry strips following preparation. The dry substance percentage, DS%, of the strips varies in this case between 12.3-13.9% with the different temperature-time combinations prior to coating, and between 27.5-29.0 after coating. In summary, the experiment shows that the coating quality of french fry strips, from the perspective of coating and DS% (as marker for nutritional value), progresses optimally with a combination of 10 minutes-80°C with a completely covering, properly adhering and smooth coating around french fry strips with a DS% of about 28% as outcome. It will be apparent that variations in these values are possible.

In a further experiment potatoes of the Evora variety were compared to potatoes of the Colomba variety. Results with conditions as discussed above show that Evora potatoes have a DS% of 15.4%. Colomba potatoes have a content of 13.2%. The obtained french fry samples displayed similar smoothness, adhesion and coverage for the applied coating as specified here with optimal coating quality at a drying time of 10 minutes at 80°C for both varieties (data not shown).

Blanching, drying and coating in this experiment increased the DS% of the french fry strips from the range 13-15% DS in raw strips to a DS% in the range of 30-34% for coated french

fries with optimal coverage, smoothness and adhesion. The increase in DS% in french fry strips as a result of the coating step was 15.3% in accordance with a computer model and was similar for both varieties, an indication that the applied coating functions similarly on raw french fry strips with differing initial values and has a measure of robustness for different potato batches

5 irrespective of variety denomination or initial DS%. Samples of the french fry strips of the Colomba and Evora varieties with drying times of 3, 5 or 10 minutes were finish-fried in an air fryer for 7 or 8 minutes at 180°C. This resulted in a DS% in the range of 36.7-45.3, depending on the conditions applied.

10 In a further experiment the influence of blanching and coating parameters on the production process of low-calory french fries was further studied with focus on coating quality and related external characteristics. The drying time of blanched samples was set here at 10 minutes 80°C, suitable conditions as found from previous experiments. The processing steps of blanching time, blanching temperature, coating time and coating temperature were studied in combination with samples of the varieties Carrera (13.8% DS) and Colomba (12.3% DS) in a complete
15 experimental design wherein the parameters were varied around the expected optima. The different treatment steps were performed as specified above in respect of preparation of samples, utilization of equipment, methods and scoring of quality characteristics.

The results show that a higher blanching temperature (80°C vs. 76°C) has a positive influence on the adhesion and smoothness of the coating for both varieties. This is in line with the
20 above discussed results. A blanching step at 80°C repeatedly gave the best coating results. A longer blanching time (10 min vs. 7.5 min) also brought about an improvement in coating quality, as found above. The blanching steps had a greater influence on the quality of the coating than on the evolution of the dry substance content. The influence on DS% was relatively small. The greatest influence on DS% and quality of the coating was exerted by the duration and temperature
25 during the coating steps, or pre-frying. The DS% as well as the adhesion and smoothness of the coating on the french fry strips increased with longer pre-frying time/coating duration (2 min vs. 1.5 min) and temperature of the oil during pre-frying/coating (170°C > 160°C > 150°C). For the production of low-calory french fries DS% is however an important parameter which has to be optimized in the finish-fried product. In addition to a properly adhering and smooth coating, the
30 mechanical strength and retention of a square strip form are moreover also good quality characteristics defining the quality of the coating process. Well-coated strips have a good square form along the length of the strips and retain this form during a rolling movement between the fingers. The inability to provide resistance to the rolling movement is an indication that the coating has been inadequately applied to the french fry strips. In the experiment the mechanical strength of
35 french fry strips was scored in response to a rolling movement between the fingers for all preparation combinations. The measurement is performed between 1 and 2 minutes after

application of the coating as an average impression of 10 strips per condition.

The results show that the mechanical strength of the coating of french fry strips increases in the same pattern as for the adhesion and smoothness of the french fry strips for both varieties. The strength is determined mainly by the combination of pre-frying time and pre-frying
5 temperature, and to some extent by the blanching conditions.

In summary, the combination of 10 minutes blanching at 80°C, 2 minutes coating at 160°C is the optimal combination resulting in a good, completely adhered, smooth coating with a good mechanical strength and a golden yellow colour and a DS% in the range of 25-29% around the optimal setting of the preparation parameters.

10 The production of low-calory french fries according to the invention requires suitable batches of potatoes which, after processing, actually produce coated french fries with the desired low nutritional value on the basis of a lower dry substance content and lower calorific value.

Described below is an experiment for assessing batches for suitability for the production of low-calory french fries with a quick test which accurately predicts the ability of potato batches to
15 relinquish water during the production and preparation of low-calory french fries.

Samples of different batches of potatoes of the Evora, Colomba and Carrera varieties in the size range of 40-70 mm were washed, peeled and processed to a total of 5 kg of french fry strips of 10 x 10 mm in the above described manner.

The strip samples were then divided into two portions of respectively 2 and 3 kilograms
20 for further experiments. On the one hand frozen coated french fry strips were prepared under optimal preparation conditions (10 minutes blanching at 80°C, 10 minutes drying at 80°C, 2 minutes pre-frying at 160°C as specified above) and assessed for relevant quality characteristics. On the other hand the ability of french fry strips to relinquish water was studied during a frying process with an incremental time series from 0 to 3 minutes in a deep-fryer as used in previously
25 described experiments. In this method 250 gram portions of french fries of the different samples were fried for a period of 0, 1, 2 and 3 minutes at a temperature of 180°C, removed from the oil at the given times, shaken to remove adhering oil and measured for dry substance content after drying for 48 hours at 80°C in a drying oven (Termaks TS9430). Evolution of dry substance content as a function of frying time was calculated with linear regression with the directional coefficient of the
30 curve as measure of water loss.

The results of the measurements show that the dry substance content of the raw french fries as used in the experiments varies between 13.2 and 18% dry substance over the different batches, varieties used and origins. After pre-frying/coating the content varies between 29.1 and 34.2%, a range similar to the above described measurements after preparation under similar
35 conditions. The dry substance evolution of french fry strips as a function of frying time (re fry curve) is to a great extent related to the dry substance content of coated french fries and is a good

parameter for the prediction of the dry substance content of coated french fries after the preparation process. There is no significant relation between the initial dry substance content of raw strips of the batches and the dry substance content of coated strips, this indicating that the dry substance evolution of strips during the frying process is not associated with this characteristic but, perhaps, with the quality and quantity of the cell walls of the batches in question. Batches of potatoes of the studied samples of three varieties in this experiment differ in the ability to relinquish water during a frying process. This is a good parameter for the prediction of the dry substance content of coated low-calory french fry strips in an optimal preparation process as measured on the basis of dry substance content. It has been found more specifically that, in the assessment of a batch for suitability, use can be made of a determination of the relation between dry substance content and frying time. A value for the directional coefficient of the curve in the range of 4-6 with as unit the percentage of dry substance per minute of frying time at a temperature of 180°C has been found suitable here for the purpose of assessing whether a batch is suitable for processing.

The specified relation between the evolution of dry substance during a drying process and the dry substance content of coated french fries following application of an optimal production process is possibly also relevant during the finish-frying process of french fries in preparation for consumption of low-calory french fries according to our invention. This relation has been further studied in further experiments in relation to the dry substance content of french fries finish-fried in the air fryer.

Coated french fries were made from potato batches of the Carrera, Colomba and Evora varieties as described above. Coated frozen french fries were finish-fried in portions of 250 g with the air fryer for a period of 80 minutes at 180°C, as specified above, and subsequently cooled rapidly to -5°C, after which the dry substance content was measured as described in the previous experiment.

The dry substance content of coated french fry strips varied between 29.1 and 34.2% for the different batches and varieties. The dry substance content of finish-fried french fries was between 38.7 and 45.4%. The dry substance content of finish-fried french fries correlated to a great extent with the dry substance evolution of french fry strips as a function of frying time, and dry substance coated french fries. These relations show that the extent to which french fry strips evolve dry substance in the preparation process is not particularly different in the individual steps of the process, but applies generally during all steps of the process. The dry substance evolution of french fry strips as a function of frying time thus has a predictive value for the dry substance content of coated french fries, but also for that of finish-fried french fries. Dry substance evolution, or water loss, is apparently a batch-related behaviour which progresses proportionally to the dry substance evolution of french fry strips as a function of frying time as determined from the above described experiments.

Low-calory coated french fries according to the invention must not only comply with nutritional value specifications but also with specific texture criteria. Coated french fries of the varieties and batches as prepared and finish-fried in above described experiments were measured for texture characteristics with the standard TPA test of Stable Micro Systems. In addition to

5 crispness (measured as breaking force F_{max} in N), the flexure distance (in millimetres) until the F_{max} value is reached, expressed as $Extn$, was also examined. This describes the breakability of french fry strips.

F_{max} varies between 1.2 and 2.1 N, which on a sensory scale corresponds to between crispy and crunchy (own observations, no data). $Extn$ varies from 2.1 to 4.3 mm, which is

10 associated with easily breakable to quite flexible. F_{max} and $Extn$ are inversely proportional/reciprocal characteristics, which is understood to mean that if the one characteristic increases, the other decreases. There are significant relations between the dry substance characteristics and the texture characteristics. Both crispness and breakability increase at higher values of the dry substance characteristics. The relations found are in line with the empirical fact

15 that crispness and breakability of finish-fried products are a function of water content.

Low-calory coated french fries with a cut size of 10 x 10 mm, which after finish-frying following preparation as described above have a dry substance content in the range of 38-43%, a crispness in the range 1.5-2.5 N and a breakability measured as the characteristic $Extn$ of < 3.3 mm, comply with the optimum profile according to the invention.

20 Low-calory coated french fries as obtained from the experiments show a surprising combination of properties. As finish-fried end product the french fries combine a conventional golden yellow colour with clear crispness of the crust, an exceptionally low dry substance content and a low calorific value based on a moist soft filling.

It will be apparent that the above discussed experiments and examples show suitable

25 ranges of conditions and/or compositions. Some variation is possible.

Coated french fries according to the invention have a significantly lower calorific value compared to regular french fries as prepared in a frying process in oil. The calorific value and nutritional value of coated french fries of the invention was measured from a series of samples of the varieties Carrera, Colomba, Evora and Innovator. Coated french fries of cut size 10 x 10 mm

30 and 12 x 12 mm were produced according to the above described procedure. The calorific and nutritional value of the coated french fry samples of the above varieties were compared after a finish-frying step in the air fryer (8 minutes at 180°C as according to above) to those of two batches of regular 10 x 10 mm french fries of the Innovator variety finish-fried in oil in a frying process of 3 minutes at 180°C. Both regular Innovator samples were produced in identical manner

35 as described above, with the exception of the coating step where the blanched and dried strips were only pre-fried in oil in the absence of the coating but with the same time duration and frying

temperature as during the coating process. French fries of the different samples were frozen in a Hobart blast chiller to -5°C immediately following deep-frying and subsequently to -20°C in the freezer prior to analysis in order to avoid drying-out and loss of moisture. Samples were stored in hermetically sealed plastic bags prior to further measurements. Nutritional value and calorific values of samples were measured for the characteristics such as available carbohydrates, total carbohydrates, energy value (kCal), energy value (kJ), fat, protein, moisture content and dietary fibre (in accordance with AOAC).

Coated french fries according to the invention typically have an energy value between 170 and 190 kCal/100 g at a cut size of 10 x 10 mm and an energy value between 160 and 180 kCal/100 g at a cut size of 12 x 12 mm, depending on the dry substance content of pre-fried coated french fries. It emerges here that 12 x 12 mm french fries of the invention have an additional decrease in energy value relative to 10 x 10 mm french fries. The influence of cut size of energy value of french fries is also known for regular french fries, although the coated french fries of the invention have an extra reduction.

When coated french fries of the invention finish-fried with an air fryer are compared to regular french fries finish-fried in oil, there is a much greater reduction in energy value. There is then an average reduction of 30% for the cut size 10 x 10 mm and as much as 33% for 12 x 12 mm french fries. With a correct choice of batch of low-calory varieties reductions in energy value are possible of up to over 40% for coated french fries according to the invention. This reduction in energy value is based on an average reduction of about 23% in available carbohydrates and a reduction of about 40% in fat content compared to regular french fries finish-fried in oil. The coating of the reference variety Innovator with the coating of the invention results in a reduction of about 10% or 18% in energy value in accordance with respective cut sizes of 10 x 10 mm and 12 x 12 mm, this being substantially due to a reduction in the fat content and a slight increase in the moisture content. The reduction obtained is however much lower than in coated french fries of the invention with the preferred varieties. Typical fat contents of coated french fries of the invention finish-fried with an air fryer vary between 7.0 and 8.0% for the 10 x 10 mm cut size and between 6.0 and 7.0% for the 12 x 12 mm cut size. Typical finished-fried coated french fries of the invention have a moisture content between 60 and 65%, this being more than a quarter more than in regular french fries finish-fried in oil (with 49.2% moisture).

The effect of the coating according to the invention on the fry colour has been researched. Fry colour of french fries occurs as a result of Maillard reactions between the reducing sugars glucose and fructose with amino acids, of which asparagine makes the largest contribution, particularly during a frying process in oil. Brown discoloration is largely a function of the concentration of the reducing sugars, amino acids, water content of the product and finish-frying temperature. Regular french fry varieties must have a low content of reducing sugars in order to

prevent too brown a colour developing during the finish-frying process (USDA colour $\neq >3$). The aim in practice is a reducing sugar content below the limit of 50-60 mg glucose & fructose/100 g in order to realize this objective. Using process technology the industry can still process potatoes with a higher sugar content than the stated norm, for instance by applying blanching and drying steps, the use of coatings, but encounters insurmountable problems with the colour of finish-fried french fries when the sum of glucose and fructose becomes higher than about 200 mg/100 g. The Carrera, Colomba, Evora varieties are distinguished by very high contents of reducing sugars, this being characteristic for varieties with a low dry substance content. Production of regular, non-coated french fries from these varieties results without exception in dark brown french fries with maximum scores on the USDA colour chart, and such french fries are unsuitable for professional applications. Innovator has the desired sugar profile for commercial professional french fry production, although there are also varieties with 50% fewer reducing sugars which perform optimally as such in respect of french fry colour. The production of coated french fries from the Carrera, Colomba and Evora varieties with the coating of the invention according to the optimal preparation method as described in previous experiments and examples results in an average fry index between 2.5 and 4.0 with a normal distribution of USDA scores for individual french fry strips between 0 and 3. Colour of finish-fried french fries was measured with a DigiEye system (Verivide) under D65 light. Twenty french fry strips per sample were laid out on a tray and photographed under D65 illumination, after which the recordings were converted to Lab.tiff files and subsequently assessed for colour with an algorithm which converted the L.a.b. values of individual french fry strips pixel-wise to USDA scores as according to the USDA colour chart classification. The average fry colour of samples on the basis of variety, cut size and coating type as measured on the USDA scale (0-4) was between 3.1 and 3.9 for the samples on the fry colour/fry index scale. This follows from $((n1 \text{ (USDA0)} \times 2) + (n2 \text{ (USDA1)} \times 3) + (n3 \text{ (USDA 2)} \times 4) + (n4 \text{ (USDA 3)} \times 5) + (n5 \text{ (USDA 4)} \times 6)) / (n1 + n2 + n3 + n4 + n5)$. The colour distribution on the USDA scales largely shows values on the USDA scale 1 and 2, with low numbers on scales 0, 3 and 4. The coating of the invention has the ability to prevent the development of brown colour in coated french fries prepared from batches with a reducing sugar content in the range of 200 to 1200 mg glucose and fructose/100 g and to reduce it to a level found in regular commercial french fries.

Also occurring in parallel with the development of brown colour during the process of frying french fries is a highly undesirable byproduct with possible harmful effects to health: acrylamide. Acrylamide contents of the uncoated french fries rise to contents of an average of 3000 $\mu\text{g/kg}$ with peak values above 4000 $\mu\text{g/kg}$. By contrast coated french fries with the coating of the invention have exceptionally low acrylamide contents in the 30-200 $\mu\text{g/kg}$ range. The coating of the invention in combination with an air fry finish-frying step results in exceptionally low

acrylamide contents.

The possibility of further reducing the fat content was studied in a further experiment with coated (pre-fried) french fry samples of the varieties Carrera (low-calory) and Innovator (reference) with a cut size of 10 x 10 mm which are prepared according to the above described optimal process and, immediately after the coating process in the oil at 160°C, had adhering oil removed using a hand-driven vegetable centrifuge with a diameter of 26 cm preheated to 60°C. The portion of french fries was centrifuged uniformly for a period of 30 seconds, then frozen as described above and stored in hermetically sealed bags prior to nutritional value analysis with the focus on fat content. Non-centrifuged french fry samples were included for comparison to the centrifuging treatment. The effect of centrifuging on coated pre-fried french fries and coated pre-fried centrifuged french fries was studied following a finish-frying process (air fryer, 8 minutes 180°C). There was a decrease in the relative fat content of the french fry samples under the influence of the centrifuging. The effect did not depend on variety (ANOVA, not significant) but was significant (ANOVA, $p < 0.05$) in the case of pre-fried coated french fries. The difference remained significant after finish-frying, although the difference did decrease after finish-frying. Pre-fried coated french fries of the invention had about 15% less fat after the centrifuge step. After finish-frying the difference amounted to 6%. This corresponds in this experiment to a decrease of 10 kCal/100 g energy value in pre-fried french fries and about 5 kCal/100 g in finish-fried product. The example shows that the fat content of coated french fries of the invention can be further reduced with specific fat-reducing measures to an energy value between 140 and 160 kCal/100 g, depending on the cut size of the french fries and the efficiency of the fat-reducing measures.

Finish-fried coated french fries of the invention have a crisp texture and low calorific value which must preferably be maintained for a specific holding time. It is usual in practice to keep prepared french fries warm during the holding time under IR heating lamps. A practical standard for shelf-life of finish-fried french fries is the ability to preserve the texture for a period of 5 minutes. Obtained results show that finish-fried coated french fries of the invention can preserve the desired crispy texture for a period of 5 minutes under heating lamps. The results also show that the use of 37% m/m batter suffices for the production of crisp coated french fries of the invention with a shelf life of 5 minutes under IR heating lamps. The energy value and related characteristics of the samples did not change significantly as a function of storage time in the studied period of 5 minutes.

In a further experiment the method with the coating according to the invention was compared to that of a coating according to patent document WO 00/28828 for the relevant product characteristics as measured and assessed in the previous examples. For this purpose coated french fries were made from a total of 14 batches of potatoes of the Evora, Carrera, Colomba and Innovator varieties with the coating of the invention and the Simplot coating as specified in said

patent document under identical batter and pick-up conditions as in the method of the invention.

The coating was used for a part of the batches on french fries with a cut size of 10 x 10 mm and for the rest of the batches on a cut size of 12 x 12 mm so as to be able to study the influence of cut size on the quality of the two coatings and the expression of quality characteristics in the prepared

5 coated french fries. The preparation of the coated french fries was performed as specified in previous examples on the basis of a blanching step of 10 minutes at 80°C, a drying step of 10 minutes at 80°C, a coating of 2 minutes at 160°C and a blast freezing step of 8 minutes at -5°C, and the samples were finally further deep-frozen to -20°C in a cold store. This combination of preparation steps resulted in coated french fries with optimal external quality for both coatings and
10 a uniform coating with good adhesion as specified above.

The results show that at the level of coated frozen french fries the Simplot coating has a lower dry substance content, and so comprises more water, compared to the coating according to the invention. The dry substance content is an average of 11.1% lower for the cut size of 10 mm and 7.6% lower for the cut size of 12 mm. The difference between the Simplot coating and the

15 coating of the invention decreases with increasing cut size in line with the absolute dry substance content of the samples (DS coating invention vs. Simplot coating for 10 mm cut size: 31.1% :

27.5%; DS coating invention vs. Simplot coating for 12 mm cut size: 28.6% : 26.4%). The difference in dry substance content between the two coatings can be attributed to the quality of the two coatings in the sense of adhesion, thickness and composition. The Simplot coating is typified

20 by a very smooth exterior and a very thin but dense and closed coating, this in contrast to the coating of the invention which is typified by a thicker, likewise smooth coating with a certain airy structure. The dense closed Simplot coating retains significantly more water during the coating process for both applied cut sizes. The frozen coated french fry samples were subsequently finish-

25 fried in the (Philips) air fryer during a preparation step of 8 minutes at 180°C and assessed for fry colour. Overall there were small, though significant differences in colour as a result of variety, cut size and choice of coating in a colour range which was acceptable in the whole range in accordance with practical standards. The coating of the invention produced coated french fries which, after finish-frying in the air fryer, had a good colour in accordance with USDA norms.

Texture was measured for both coatings with the above discussed instrument-measured
30 texture characteristics Fmax (N) and extension (millimetres) of the coated french fry batches on the basis of the two coatings for the cut sizes 10 x 10 mm and 12 x 12 mm. In addition to instrument measurements, a sensory assessment of the finish-fried french fry samples was made by a panel for crispness with a scale of 1 (not crunchy) to 9 (very crunchy). Results are included in the following table 7.

variety/sample	cut size	coating	Extension (mm)	Fmax (N)	crunchy (1-9)	variety/sample	cut size	coating	Extension (mm)	Fmax (N)	Crunchy (1-9)
Carrera 12	10x10	Simplot	5.4	1.0	1	Carrera 13	12x12	Simplot	4.4	1.5	1
Colomba 2	10x10	Simplot	4.5	0.9	3	Carrera 14	12x12	Simplot	4.4	1.7	2
Colomba 4	10x10	Simplot	5.1	0.8	2	Carrera 3	12x12	Simplot	4.3	1.5	1
Innovator 23	10x10	Simplot	2.2	2.3	5	Carrera 9	12x12	Simplot	4.8	1.6	2
Innovator 27	10x10	Simplot	1.5	2.9	5	Colomba 8	12x12	Simplot	3.5	1.8	1
Carrera 12	10x10	Standard	5.9	0.7	7	Innovator 25	12x12	Simplot	2.8	3.3	4
Colomba 4	10x10	Standard	5.7	0.8	7	Carrera 13	12x12	Standard	6.2	1.9	8
Evora 10	10x10	Standard	5.3	1.2	8	Carrera 14	12x12	Standard	6.9	1.6	7
Evora 6	10x10	Standard	5.8	1.3	8	Carrera 3	12x12	Standard	6.6	1.3	8
Innovator 23	10x10	Standard	4.9	2.0	8	Colomba 5	12x12	Standard	5.6	1.0	8
Innovator 27	10x10	Standard	4.4	2.4	9	Colomba 8	12x12	Standard	6.1	2.1	9
						Innovator 25	12x12	Standard	5.0	3.0	9
average	10x10	Standard	5.3	1.4	7.8	average	12x12	Standard	6.1	1.8	8.2
average	10x10	Simplot	3.8	1.6	3.2	average	12x12	Simplot	4.0	1.9	1.8
ANOVA			p<0.05	ns	p<0.05	ANOVA			p<0.05	ns	p<0.05

Table 7: comparison of coatings

The results show that the characteristic of extension, the distance covered until french fry strips break in a breaking test, is significantly higher for french fries with the coating of the invention. The strips coated according to the invention provide longer resistance to breakage during the breaking test than the strips with the Simplot coating. The differences in breaking speed are in line with the sensory crispness of the samples. The french fry strips with a Simplot coating are not crisp, have a thin and tough structure of the coating and french fry strips on the basis of this coating provide a soft, moist sensation as also detected for soft regular french fries which cannot be finish-fried crisply (so-called limps). The french fry strips with a Simplot coating are therefore not suitable for consumption. The french fry strips of the invention have a crisp structure, in respect of texture sensation as well as in terms of sound during the chewing process. The strips combine a crispy crust with a soft moist filling. There are relatively small differences in detected texture characteristics in the two different cut sizes. For the coating of the invention 10 x 10 mm and 12 x 12 mm are of substantially similar crispness. In the Simplot coating the crispness of 12 x 12 mm strips is even softer and more moist than of the 10 x 10 mm strips. This demonstrates the better structure of the product with the coating according to the invention. The coating of the invention and the Simplot coating contrast in water-retaining capacity (Simplot >> coating of the invention), structure of the coating (Simplot: tough and thin; coating of the invention: airy and thicker), texture of the coating (Simplot: tough, not crisp; coating of the invention: crisp and firm).

The present invention is by no means limited to the above described preferred embodiments thereof. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Coating composition for a low-calorie potato product for finish-frying, such that after finish-frying french fries with a cut size of 10 x 10 mm or larger as potato products have a dry substance content in the range of 38-43% and a crispness in the range of 1.5 – 2.5 Newton, with the composition comprising by weight, relative to the weight of the composition:

- 30-60% modified starch comprising high-amylose starch;

- 20-30% flour;

- 5-20% dextrin;

- 2-10% unmodified starch; and

- 0.01-2% carbonate,

wherein the high-amylose starch is a starch with at least a content of 60% amylose.

2. Coating composition as claimed in claim 1, wherein the modified starch content lies in the range of 30-50%.

3. Coating composition as claimed in claim 1 or 2, wherein the modified starch comprises 10-25% acetylated starch of the content of modified starch.

4. Coating composition as claimed in claim 1, 2 or 3, further comprising a percentage by weight of 0.01-1%, and preferably 0.01-0.5% of thickener.

5. Coating composition as claimed in claim 4, wherein the thickener comprises xanthan.

6. Coating composition as claimed in one or more of the foregoing claims, wherein the carbonate includes bicarbonate such that the percentage by weight of the bicarbonate lies in the range of 0.01-1%, preferably in the range of 0.01-0.5% and most preferably in the range of 0.01-0.1%.

7. Coating composition as claimed in one or more of the foregoing claims, further comprising a percentage by weight of 5-10% of mineral salts.

8. Potato product for finish-frying in a coating process provided with a coating composition as claimed in one or more of the foregoing claims.

9. Potato product for finish-frying as claimed in claim 8, comprising a percentage by weight of the coating composition relative to the end product in the range of 5-18%, preferably 5-16%, more preferably 10-15%, still more preferably 11-15%, and most preferably 12-14%, obtained from a coating process.

10. Potato product for finish-frying as claimed in claim 8 or 9, comprising french fries, wherein the potato product is preferably prepared from potato varieties with an underwater weight equal to or lower than 300 g/5 kg, and/or wherein the potato varieties preferably comprise Colomba, Carrera and Evora.

11. Method for providing a low-calorie potato product for finish-frying, comprising of:

- providing the potato product from a starting material; and
- applying a coating composition to the potato product for finish-frying as claimed in one or more of the foregoing claims.

5 12. Method as claimed in claim 11, wherein the coating is applied to the potato product after blanching and before pre-frying and deep-freezing of the potato product, and wherein the coating is preferably applied with a suspension provided with a dry substance content in the range of 30-55%, preferably in the range of 35-45%.

10 13. Method as claimed in claim 11 or 12, further comprising the step of modifying the coating composition on the basis of the origin of the potato product, storage life and/or storage conditions, wherein the coating composition is modified by varying ratio of the weight of the composition of the modified starch and the unmodified starch.

15 14. Method as claimed in one or more of the claims 11-13, further comprising the step of selecting a batch for the purpose of providing a low-calorie potato product for finish-frying, comprising of determining the dry substance content for a batch as a function of frying time, wherein a batch is preferably assessed as suitable if the directional coefficient for the relation between dry substance content and frying time lies in the range of 4-6% dry substance per
20 minute of frying time at a frying temperature of 180°C.

15. Use of the coating composition as claimed in one or more of the claims 1-7, resulting in a potato product provided with a:

- calorific value lower than 190 kCal/100 g;
- 25 - content of available carbohydrates of 20-24%;

- acrylamide lower than 100 µg/kg;
- colour in accordance with USDA ≤ 3 ;
- fat content in the range of 5-7%;
- texture having a breaking value in the range of 1.5-2.5 Newton; and
- shelf life of 5 minutes in holding time period at about 60°C under a heating lamp.