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(54) Title: POTATO PROTEIN COAGULATE

(57) Abstract: The invention pertains to potato protein coagulate which is pseudo-plastic.

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POTATO PROTEIN COAGULATE

The present invention relates to potato protein coagulate.

Potato protein coagulates have been described in the art. Coagulation is an effective way to isolate potato proteins from potato fruit juice. One of the drawbacks is that the obtained potato protein coagulates generally render food products containing these coagulates gritty or sandy. In EP 3 373 739 and WO 2016/133448 it is indicated that the particle size is contributing mainly to grittiness, and that reducing the particle size to d90 values of around 45 μm overcomes the grittiness. The inventors have found that particle size is not the only parameter important for determining the sensory properties of the coagulates in food products.

The objective of the present invention is to provide a novel potato protein coagulate.

The invention pertains to a potato protein coagulate which is pseudo-plastic. The invention further pertains to a potato protein coagulate exhibiting shear thinning behaviour. With “shear thinning behaviour”, “pseudo-plastic” or “pseudo-plastic behaviour” is meant that the viscosity of an aqueous suspension of the potato protein coagulate decreases under increased shear strain. In particular, this behaviour is determined in an aqueous suspension comprising 5 wt% of the potato protein coagulate of the invention, based on the total weight of the aqueous suspension. It was found that conventional potato protein coagulates obtained under relatively severe coagulation conditions (in particular at temperatures exceeding 100°C), having been dried at higher temperature and/or conditions at which the coagulates form larger agglomerates and after milling such as in EP 3 373 739, WO 2016/133448 and DE 2 500 200 do not exhibit shear thinning behaviour but instead dilatant or shear thickening behaviour. With “shear thickening behaviour”, “dilatant” or “dilatant behaviour” is meant that the viscosity of an aqueous suspension of the potato protein coagulate increases under increased shear strain. The potato protein coagulate of the invention has a higher viscosity compared to conventional potato protein coagulate. This is believed to be due to the different surface properties of the inventive coagulate, which generally has a better interaction with the surrounding water molecules. The inventive potato protein coagulate further exhibits a slower sedimentation rate compared to conventional potato protein coagulates. Moreover, the density of the coagulate of the invention is generally lower than the density of conventional coagulates. In addition, the water holding capacity of the inventive coagulate is generally larger compared to conventional potato protein coagulate. The improved properties of the inventive coagulate allow for a better processing and an easier distribution in various matrices including food products. The inventive potato protein coagulate generally do not cause a gritty mouthfeel when used in food products. In fact, a yoghurt comprising the inventive coagulate, and in particular the

suspension of the inventive (non-dried) potato protein coagulate, was found to be creamy. The coagulate of the invention can generally be used in a wide variety of food applications, and at higher concentrations compared to conventional coagulates without significantly impacting the sensory properties of the food product. The inventors found that the coagulates of the invention can be obtained without the necessity to mill the coagulate to a smaller particle size as the initial particle size of the coagulates after the coagulation process is small which does not require any further processing such as milling. The inventive coagulates which have not been dried and which are generally obtained in suspension, preferably an aqueous suspension, have superior properties over their dried counterpart, in particular the viscosity is even higher, the sedimentation behaviour improved and the food products containing the non-dried coagulate have improved sensory properties.

In one embodiment, the ratio of the viscosity at a shear rate of 50/s and at a shear rate of 10/s is at most 1. Preferably, the ratio of the viscosity at a shear rate of 50/s and at a shear rate of 10/s is at most 0.95, more preferably at most 0.9, even more preferably at most 0.8, even more preferably at most 0.7, even more preferably at most 0.6 and most preferably at most 0.5, and preferably at least 0.05, more preferably at least 0.1 and most preferably at least 0.2. The viscosity at different shear rates can be determined using any conventional techniques. Preferably, the viscosity is measured using a rheometer such as an Anton Paar Rheometer (MCR 302, cup and spindle CC27). Further details of this measurement are described in the Examples.

In one embodiment, the potato protein coagulate of the invention has a viscosity of at least 2 mPa.s at a shear rate of 10/s and at 20°C when measured in an aqueous suspension comprising 5 wt% of the potato protein coagulate, based on the total weight of the aqueous suspension. Preferably, the viscosity is at least 5 mPa.s, more preferably at least 10 mPa.s, even more preferably at least 15 mPa.s and most preferably at least 20 mPa.s, and preferably at most 50 mPa.s, more preferably at most 40 mPa.s and most preferably at most 30 mPa.s. The viscosity can be determined using any conventional techniques. Preferably, the viscosity is measured using a rheometer such as an Anton Paar Rheometer (MCR 302, cup and spindle CC27). Further details of this measurement are described in the Examples.

In one embodiment, the potato protein coagulate of the invention has a viscosity of at least 2 mPa.s at a shear rate of 50/s and at 20°C when measured in an aqueous suspension comprising 5 wt% of the potato protein coagulate, based on the total weight of the aqueous suspension. Preferably, the viscosity is at least 3 mPa.s, more preferably at least 5 mPa.s, even more preferably at least 8 mPa.s and most preferably at least 10 mPa.s, and preferably at most 50 mPa.s, more preferably at most 30 mPa.s and most preferably at most 20 mPa.s.

The viscosity can be determined using any conventional techniques. Preferably, the viscosity is measured using a rheometer such as an Anton Paar Rheometer (MCR 302, cup and spindle CC27). Further details of this measurement are described in the Examples.

In one embodiment, the potato protein coagulate according to invention has a suspension volume index of at least 10 mL/g. The suspension volume index (in mL/g) is determined in an aqueous suspension containing 3 wt% potato protein coagulate after 2 hours of settling at 20°C and is calculated as the ratio of the suspension volume (in mL/L) and the coagulate concentration (in g/L) times 1000. The suspension volume is determined by the volume at the upper level of the suspension. Preferably, the suspension volume index is at least 12 mL/g, more preferably at least 15 mL/g, even more preferably at least 20 mL/g, and most preferably at least 25 mL/g, and preferably at most 33.3 ml/g, more preferably at most 33 mL/g and most preferably at most 30 mL/g.

In one embodiment, the potato protein coagulate according to invention has a suspension volume index (24h) of at least 10 ml/g. The suspension volume index (in mL/g) is determined in an aqueous suspension containing 3 wt% potato protein coagulate after 24 hours of settling at 20°C and is calculated as the ratio of the suspension volume (in mL/L) and the coagulate concentration (in g/L) times 1000. The suspension volume is determined by the volume at the upper level of the suspension. Preferably, the suspension volume index is at least 12 mL/g, more preferably at least 15 mL/g, even more preferably at least 20 mL/g, and most preferably at least 25 mL/g, and preferably at most 33.3 ml/g, more preferably at most 33 mL/g and most preferably at most 30 mL/g.

In one embodiment, the potato protein coagulate according to invention has a sedimentation volume index of at most 1 ml/g. The sedimentation volume index (in mL/g) is determined in an aqueous suspension containing 3 wt% potato protein coagulate after 2 hours of settling at 20°C and is calculated as the ratio of the sedimentation volume (in mL/L) and the coagulate concentration (in g/L) times 1000. The sedimentation volume is determined by the volume at the upper level of the sedimentation in the suspension. A sedimentation level can be determined while the suspension above this level is still present. In such case, both a suspension level and a sedimentation level can be determined. It is also envisaged that the particles in the suspension have sedimented and only a sedimentation level can be determined. Preferably, the sedimentation volume index is at most 0.7 mL/g, more preferably at most 0.5 mL/g, even more preferably at most 0.2 mL/g, and most preferably at most 0.1 mL/g, and preferably at least 0.001 ml/g, more preferably at least 0.005 mL/g and most preferably at least 0.01 mL/g. In a preferred embodiment, no sedimentation is present. In such case, the sedimentation volume index is 0 mL/g.

In one embodiment, the potato protein coagulate according to invention has a sedimentation volume index (24h) of at most 1 ml/g. The sedimentation volume index (24h) (in mL/g) is determined in an aqueous suspension containing 3 wt% potato protein coagulate after 24 hours of settling at 20°C and is calculated as the ratio of the sedimentation volume (in mL/L) and the coagulate concentration (in g/L) times 1000. The sedimentation volume is determined by the volume at the upper level of the sedimentation in the suspension. A sedimentation level can be determined while the suspension above this level is still present. In such case, both a suspension level and a sedimentation level can be determined. It is also envisaged that the particles in the suspension have sedimented and only a sedimentation level can be determined. Preferably, the sedimentation volume index (24h) is at most 0.7 mL/g, more preferably at most 0.5 mL/g, even more preferably at most 0.2 mL/g, and most preferably at most 0.1 mL/g, and preferably at least 0.001 ml/g, more preferably at least 0.005 mL/g and most preferably at least 0.01 mL/g. In a preferred embodiment, no sedimentation is present. In such case, the sedimentation volume index (24h) is 0 mL/g.

In a preferred embodiment, the suspension volume index and the sedimentation volume index are not equal. Preferably, the suspension volume index is higher than the sedimentation volume index. In a preferred embodiment, the suspension volume index (24h) and the sedimentation volume index (24h) are not equal. Preferably, the suspension volume index (24h) is higher than the sedimentation volume index (24h).

In a further embodiment, the potato protein coagulate according to the invention has a particle size distribution comprising a main peak and a second peak with the top of the second peak being at a smaller particle size than the top of the main peak. The main peak is determined as the peak with the highest intensity (or highest peak) and the second peak is determined as the shoulder of the main peak, which may partially overlap with the main peak, and which peak maximum is located at smaller particle size than the main peak. The particle size distribution can be determined using any conventional techniques such as laser diffraction using a Malvern Mastersizer. The coagulates of the invention have been prepared using mild coagulation conditions which allows for the production of relatively small coagulate particles which do not require reduction of particle size e.g. by milling. It is believed that this production process leads to a particle size distribution that reveals a main peak and a shoulder on the lower particle size side of the main peak. This distribution was found to remain after drying and after milling, even though the position of the main peak may shift to higher or lower particle size. In comparison, the particle size distribution is different when more severe coagulation is used as is shown in Figure 4 in EP 3 373 739 which consistently reveals a shoulder on the right-hand side (the higher particle size side) of the main peak.

In one embodiment, the potato protein coagulate of the invention has the d90 of at most 50 μm. preferably, the inventive coagulate has a d90 of at most 40 μm, more preferably at most 35 μm, even more preferably at most 30 μm and most preferably at most 25 μm, and preferably at least 1 μm, more preferably at least 2 μm and most preferably at least 5 μm. The particle size distribution, in particular the d90 value, is determined using conventional techniques such as laser diffraction using a Malvern Mastersizer. The inventors have found that the particle size of the protein coagulate is not the most determining factor for the absence of grittiness in food products as is suggested in EP 3 373 739 and WO 2016/133448. Instead the surface properties of the potato protein coagulate seem to be more important as is indicated above. A smaller particle size of the inventive coagulate is advantageous for its surface properties, its further processing ease and sensory properties.

In one embodiment, the potato protein coagulate of the invention has the D[4,3] of at most 50 μm. preferably, the inventive coagulate has a D[4,3] of at most 40 μm, more preferably at most 35 μm, even more preferably at most 30 μm and most preferably at most 25 μm, and preferably at least 1 μm, more preferably at least 2 μm and most preferably at least 5 μm. The particle size distribution, in particular the D[4,3] value, is determined using conventional techniques such as laser diffraction using a Malvern Mastersizer.

In one embodiment, the potato protein coagulate was not dried and/or milled.

In a further embodiment, the potato protein coagulate of the invention comprises at most 150 ppm glycoalkaloids. Preferably, the inventive coagulate comprises at most 125 ppm glycoalkaloids, more preferably at most 100 ppm glycoalkaloids, even more preferably at most 75 ppm glycoalkaloids and most preferably at most 50 ppm glycoalkaloids, and preferably at least 0.1 ppm glycoalkaloids, more preferably at least 1 ppm glycoalkaloids and most preferably at least 5 ppm glycoalkaloids.

In a further embodiment, the potato protein coagulate of the invention comprises at most 150 ppm sulfite. Preferably, the inventive coagulate comprises at most 125 ppm sulfite, more preferably at most 100 ppm sulfite, even more preferably at most 75 ppm sulfite and most preferably at most 50 ppm sulfite, and preferably at least 0.1 ppm sulfite, more preferably at least 1 ppm sulfite and most preferably at least 5 ppm sulfite.

In one embodiment of the invention, the potato protein coagulate comprises at least 60 wt% protein. Preferably, the inventive coagulate comprises at least 70 wt% protein, more preferably at least 80 wt% protein, even more preferably at least 85 wt% protein and most preferably at least 90 wt% protein, and preferably at most 99 wt% protein, more preferably at most 96 wt% protein and most preferably at most 95 wt% protein, based on the total dry weight of the potato

protein coagulate. The total dry weight is defined as the total weight of the potato protein coagulate without water.

In one embodiment of the invention, the potato protein coagulate comprises at least 60 wt% water. Preferably, the inventive coagulate comprises at least 70 wt% water, more preferably at least 80 wt% water, even more preferably at least 85 wt% water and most preferably at least 90 wt% water, and preferably at most 99 wt% water, more preferably at most 96 wt% water and most preferably at most 95 wt% water, based on the total weight of the potato protein coagulate.

In one embodiment, the potato protein coagulate comprises an additive. The additive can be any additive known in the art. Such additives include pigments, (inorganic) fillers, flavouring agents, anti-oxidants, preservatives, sugars, stabilisers, hydrocolloids, fibers, other proteins and colouring agents.

In one embodiment of the invention, the potato protein coagulate comprise at least 0.01 wt% of the additive. Preferably, the inventive coagulate comprises at least 0.05 wt% additive, more preferably at least 0.1 wt% additive, even more preferably at least 0.5 wt% additive and most preferably at least 1 wt% additive, and preferably at most 60 wt% additive, more preferably at most 50 wt% additive and most preferably at most 40 wt% additive, based on the total weight of the potato protein coagulate.

The amounts of potato protein coagulate, water, additives and any other components add up to 100% by weight of the potato protein coagulate.

The invention further pertains to an aqueous suspension comprising a potato protein coagulate which is pseudo-plastic. Particularly advantageous is an aqueous suspension comprising non-dried potato protein coagulate. The non-dried coagulate exhibits a stronger shear thinning effect. Moreover, the suspension will have a higher viscosity than dried potato protein coagulate in accordance with the invention.

In one embodiment of the invention, the aqueous suspension comprises at least 1 wt% of the potato protein coagulate. Preferably, the inventive aqueous suspension comprises at least 2 wt% potato protein coagulate, more preferably at least 5 wt% potato protein coagulate, even more preferably at least 10 wt% potato protein coagulate, even more preferably at least 12 wt% potato protein coagulate, even more preferably at least 15 wt% potato protein coagulate, and most preferably at least 20 wt% potato protein coagulate, and preferably at most 99 wt% potato protein coagulate, more preferably at most 90 wt% potato protein coagulate and most

preferably at most 80 wt% potato protein coagulate, based on the total weight of the aqueous suspension.

In one embodiment of the invention, the aqueous suspension comprises at least 10 wt% water. Preferably, the inventive suspension comprises at least 30 wt% water, more preferably at least 40 wt% water, even more preferably at least 50 wt% water and most preferably at least 60 wt% water, and preferably at most 99 wt% water, more preferably at most 96 wt% water and most preferably at most 95 wt% water, based on the total weight of the aqueous suspension.

In one embodiment, the inventive aqueous suspension has a water activity of at most 0.6. Preferably, the water activity is at most 0.55, more preferably at most 0.5, even more preferably at most 0.45, even more preferably at most 0.4, even more preferably at most 0.35 and most preferably at most 0.3, and preferably at least 0.01, more preferably at least 0.05 and most preferably at least 0.1. The water activity can be determined using any conventional technique. Preferably, the water activity is measured using Novasina LabMaster Neo at 25 °C.

In one embodiment, the aqueous suspension comprises an additive. The additive can be any additive known in the art. Such additives include pigments, (inorganic) fillers, flavouring agents, anti-oxidants, preservatives, sugars, stabilisers, hydrocolloids, fibers, other proteins and colouring agents.

In one embodiment, the additive is a preservative. The preservative serves to reduce or diminish the microbial growth over a prolonged period of time. Preferably, the preservative is a food-grade preservative. The preservative can be any preservative known in the art suitable for preserving the inventive aqueous suspension. Examples of such preservatives include benzoates such as benzoic acid, potassium benzoate, sodium benzoate, calcium benzoate; sorbates such as calcium sorbate, sodium sorbate and potassium sorbate; organic acids such as erythorbic acid, lactic acid and acetic acid; salts such as sodium chloride and potassium nitrate; and sugars such as sucrose, glucose and fructose.

In one embodiment of the invention, the aqueous suspension comprises at least 0.01 wt% of the additive. Preferably, the inventive coagulate comprises at least 0.05 wt% additive, more preferably at least 0.1 wt% additive, even more preferably at least 0.5 wt% additive and most preferably at least 1 wt% additive, and preferably at most 60 wt% additive, more preferably at most 50 wt% additive and most preferably at most 40 wt% additive, based on the total weight of the aqueous suspension.

The amounts of potato protein coagulate, water, additives and any other components add up to 100% by weight of the aqueous suspension.

The invention further pertains to a food product comprising the potato protein coagulate of the invention. The food product can be any food product known in the art wherein the inventive filaments can be used. Examples of such food products include meat substitutes or alternatives, fish substitutes or alternatives, breakfast cereals, cereal bars, protein bars, pastry, snacks and salads. Snacks are preferably chosen from the group consisting of plant-based meat snacks, vegan meat sticks, pizza bites and vegan protein bites.

In another embodiment, the food product is a vegetarian or vegan food product, preferably a vegetarian or vegan meat substitute or alternative, fish substitute or alternative, breakfast cereal, cereal bar, protein bar, pastry, snack or salad. In a preferred embodiment, the food product does not comprise animal-derived ingredients.

In one embodiment of the invention, the food product is a burger, preferably a vegetarian or vegan burger. In a further embodiment, the food product is a meat alternative, preferably a vegan burger.

The food product can be in any form known in the art. Examples include liquids, such as dispersions, creams, emulsions and solutions, and solids, such as granules, flakes, foams, gels or powders.

In one embodiment of the invention, the food product comprises at least 1 wt% of the potato protein coagulate. Preferably, the inventive food product comprises at least 2 wt% potato protein coagulate, more preferably at least 5 wt% potato protein coagulate, even more preferably at least 10 wt% potato protein coagulate and most preferably at least 15 wt% potato protein coagulate, and preferably at most 90 wt% potato protein coagulate, more preferably at most 80 wt% potato protein coagulate and most preferably at most 70 wt% potato protein coagulate, based on the total weight of the food product.

In one embodiment, the food product comprises a food-grade additive or food ingredient. Such a food-grade additive can be any food-grade additive known in the art. Examples of such food-grade additives include flavouring agents, colouring agents, preservatives, proteins, liquids such as water, anti-oxidants, stabilisers, hydrocolloids, other proteins and (dietary) fibers.

In one embodiment of the invention, the food product comprises at least 0.01 wt% of the food-grade additive. Preferably, the inventive food product comprises at least 0.05 wt% food-grade additive, more preferably at least 0.1 wt% food-grade additive, even more preferably at least 0.5 wt% food-grade additive and most preferably at least 1 wt% food-grade additive, and preferably at most 99 wt% food-grade additive, more preferably at most 90 wt% food-grade

additive and most preferably at most 80 wt% food-grade additive, based on the total weight of the food product.

The amounts of potato protein coagulate, food-grade additives and any other components add up to 100% by weight of the food product.

The invention further pertains to the use of potato protein coagulate being pseudoplastic in food products.

The invention further pertains to a method of producing potato protein coagulate which is pseudo-plastic comprising the steps of:

(a) providing a potato fruit juice comprising potato proteins;
(b) optionally removing starch and fibers from the potato fruit juice;
(c) optionally removing glycoalkaloids and/or phenolic compounds;
(d) adjusting the pH of the potato fruit juice to a value between 4 and 5;
(e) coagulating the potato protein at a temperature between 70 and 90°C to obtain a suspension comprising potato protein coagulate;
(f) optionally removing glycoalkaloids and/or phenolic compounds; and
(g) optionally drying the potato protein coagulate.

With this process the potato protein coagulate of the invention can be prepared. The coagulation conditions of the inventive process are relatively mild, in particular at low temperatures and specific pH. These mild conditions allow for the production of a potato protein coagulate with pseudo-plastic behaviour. The surface properties of the coagulate particles are different from potato protein coagulated at higher temperatures and higher pH values, which leads to shear thinning behaviour and/or an increased viscosity of a suspension. Moreover, the particle size of all the coagulate particles is generally lower than obtained with conventional processes. In addition, the particle size distribution of the coagulate particles differs, i.e. next to the main peak a shoulder on the smaller particle size side is observed. The process furthermore has the advantage of requiring less energy and being less complex.

In step (a) a potato fruit juice comprising potato proteins is provided. These potato proteins are generally soluble in water at the right pH. The potato fruit juice is obtained from potato and is generally obtain ed after removal of potato starch and fibers. When necessary further removal of starch and/or fibers from the potato fruit juice can be performed in accordance with (optional) step (b) of the inventive method. Such removal can be performed using techniques known in the art including pH adjustment, centrifugation and/or filtration.

In optional step (c) of the inventive method, glycoalkaloids and phenolic compounds are removed. The glycoalkaloids and phenolic compounds may lead to a potato protein coagulate

with disadvantageous sensory properties such as colour and taste. Preferably, the total glycoalkaloid content in the obtained potato protein coagulate is below 150 ppm. Such removal can be performed using conventional techniques such as washing and filtration including microfiltration, ultrafiltration and diafiltration.

In step (d), the pH of the potato fruit juice is adjusted to a value between 4 and 5. This pH adjustment provides for a more efficient coagulation, a higher yield of the inventive coagulate and an improved washing efficiency of the potato protein coagulate. Such adjustment to the desired pH can be performed using an organic acid such as lactic acid and acetic acid or an inorganic acid such as hydrogen chloride or hydrogen sulphate. Preferably, the acid used is an inorganic acid.

The coagulation step of step (e) is performed by coagulating the potato protein at a temperature between 70 and 90°C. In this way, a suspension comprising potato protein coagulate is obtained. The coagulation temperature is paramount to obtain a potato protein coagulate which is pseudo-plastic as described above. Coagulation at temperature above 100°C as described in EP 3 373 739 and WO 2016/133448 generally leads to coagulate particles with a much higher particle size which do not exhibit shear thinning behaviour. The coagulation step can be performed in a batch reactor or in continuous mode e.g. in one or more heat exchangers or heated pipes.

In optional step (f) of the inventive method, glycoalkaloids and phenolic compounds are removed. The glycoalkaloids and phenolic compounds may lead to a potato protein coagulate with disadvantageous sensory properties such as colour and taste. Preferably, the total glycoalkaloid content in the obtained potato protein coagulate is below 150 ppm. Such removal can be performed using conventional techniques such as washing and filtration including microfiltration, ultrafiltration and diafiltration. It is contemplated that the glycoalkaloids and phenolic compounds are removed in either step (c) or step (f), or in both steps (c) and (f).

In optional step (g), water can be removed from the suspension comprising the potato protein coagulate using any method known in the art. Such methods include filtration, microfiltration, ultrafiltration, pressing, decantation and evaporation.

In optional step (h) the suspension comprising potato protein coagulated is dried. The drying can be performed using any method known in the art. Preferably, the drying is performed under mild conditions. Examples of suitable drying methods include spray drying, freeze drying and fluidized bed drying. Flash drying as described in the prior art was found to be too harsh

as agglomeration of the coagulate into large(r) particles is observed, whereby the potato protein coagulate moreover loses its shear thinning behaviour.

The aqueous suspension of the invention can be obtained in steps (e) and (f). This aqueous suspension may further require the removal of part of its water in order to increase the concentration of the potato protein coagulate. Additionally or alternatively, additives such as a preservative may be added to the aqueous suspension.

The invention is exemplified in the following Examples.

Examples

Example 1: potato protein coagulate

Production of potato fruit juice (PFJ): PFJ was made from 6 kg Fontane potatoes (freshly harvested and washed) by using a lab scale angel juicer. 1.5 g bisulfite per kg potatoes was added in order to prevent oxidation of polyphenols. The PFJ was centrifuged to remove the starch. The pH of the clarified PFJ (2840 g) was adjusted to pH 4.5 by using sulfuric acid solution.

Concentration of PFJ by ultrafiltration: The PFJ was concentrated by using a 100 kDa flat sheet membrane (400 cm^2). A volume concentration factor of 6 was applied.

Dialysis of concentrated PFJ: the concentrated PFJ was dialyzed by using the same membrane, in order to wash out glycoalkaloids and polyphenols. A diafiltration factor (w/f) of 5 was applied.

Dilution of retentate and addition of sugar: the final retentate was diluted with demineralized water so that 50% of the volume of the initial amount of PFJ was obtained. After dilution a certain amount of sucrose was added to the diluted retentate, to obtain a sugar content in the final dried product of 0.5% on dry weight (i.e. 5g/kg dry matter).

Coagulation: The diluted retentate is coagulated by incubating for 30 minutes at 90°C whilst stirring. Small coagulated protein particles were formed as suspended particles in the surrounding liquid.

Filtration: the coagulate was filtered by using a Buchner funnel (filter paper 1µm) at a temperature of 80°C. Part of the Buchner filtrate was added to the coagulate cake (dry matter of 20 wt%).

Drying: the coagulate cake was spray dried using a spray dryer (Buchi B-191).

The coagulate cake (or aqueous suspension) and the dried coagulate powder were analyzed. The coagulate cake and coagulate powder contain 91.6 wt% protein (on dry weight) as measured using the Kjeldahl method (with N*6.25). The glycoalkaloids content is 23 ppm, of which 22 ppm is α-solanine and 0.7 ppm α-chaconine, as measured using LC-MS. The sucrose content was 0.21 wt% as measured with HPAEC-PAD.

The potato protein coagulate particles in the coagulate cake have a d90 of 44 μm and a D[4,3] of 21.8 μm. The potato protein coagulate particles in the dried powder have a d90 of 111 μm

and a D[4,3] of 35.3 μm. The d90 and D[4,3] values were determined using a Malvern Mastersizer (in suspension).

A 5 wt% aqueous suspension of the potato protein coagulate particles in the coagulate cake and in the dried powder demonstrated shear thinning or pseudoplastic behaviour.

Yoghurts comprising the potato protein coagulate in the coagulate cake and in the dried powder were prepared according to the following recipe:

Yoghurt full fat (3% fat) ex Friesland Campina	140 g
Tap water	47 g
Sucrose	8 g
Protein coagulate according to the invention	5 g

The yoghurts were prepared by the following steps:

1) weight in all ingredients
2) add sucrose and protein coagulate to yoghurt and stir for 10 minutes
3) add tap water and stir for 5 minutes
4) Store at 4-7°C; serve at 7-12°C

The resulting yoghurts were sensory evaluated by a trained panel of 5 people and scored on grittiness. The yoghurt comprising the potato protein coagulate in the coagulate cake was pasty, creamy and smooth. No large, gritty particles were observed. The yoghurt was neutral in taste (no off flavour or bitter taste).
The yoghurt comprising the potato protein coagulate in the dried powder was not gritty and neutral in taste (no off flavour or bitter taste).

<u>Examples 2 and 3: potato protein coagulate</u>

PFJ was made from 24100 kg Fontane potatoes (freshly harvested and washed) by using a rasp. 1.5 g bisulfite per kg potatoes was added in order to prevent oxidation of polyphenols. The PFJ was centrifuged and decanted to remove the starch. The pH of the clarified PFJ (11890 kg) was adjusted to pH 4.5 by using sulfuric acid solution.

The PFJ was subsequently heated to 90°C and maintained at 90°C for 5 minutes, after which the suspension was cooled to 50°C. The solids were separated in a sedicanter (feed rate 800 L/h). The obtained solids were washed with water having a pH of 4.0 (using sulfuric acid) at a temperature of 80°C. Subsequently, the suspension was fed to a sedicanter and the solids separated. The solids were again washed with water having a pH of 5.0 (using sulfuric acid)

at room temperature. The suspension was then fed into a sedicanter and the coagulate cake (21 wt% dry matter) was removed. The obtained coagulate cake is an aqueous suspension (Example 2) in accordance with the invention.

The coagulate cake was dried using a spray dryer (Buchi B-191) to obtain a coagulate powder in accordance with the invention (Example 3).

The same experiment was repeated three times with the exception that the coagulate cake is dried in a flash dryer. The three batches of dried coagulate powder were combined to form a mixed coagulate powder not in accordance with the invention (Comparative Example A). The mixed coagulate powder of Comparative Example A is milled to reduce the particle size to obtain a milled coagulate powder not in accordance with the invention (Comparative Example B).

The four samples were analyzed using methods as described in Example 1. The analytical data is provided in the Table below.

Table 1 Chemical data and particle size

Example	Protein (wt%)	d90 (μm)	D[4,3] (μm)	TGA (ppm)	Sulfite (ppm)
2	75	77.3	31.2	69	77
3	75	14.3	5.8	69	77
A	80	90.2	53.9	131	20
B	80	27.3	15.3	131	20

Aqueous suspensions containing 5 wt% of potato protein coagulate of the samples were prepared. The viscosity of these suspensions was determined after 100 seconds of shear at constant shear rates of 10/s and 50/s at a temperature of 20°C using an Anton Paar Rheometer (MCR302, cup and spindle CC27). The viscosity is tabulated in Table 2.

Table 2 Viscosity data at constant shear rate

Example	Viscosity (mPa.s) at 10/s	Viscosity (mPa.s) at 50/s
2	22.96	8.02
3	2.32	2.17
A	1.15	1.31
B	1.32	1.38

From Table 2 it can be deduced that the coagulates of Examples 2 and 3 have shear thinning effect, i.e. the viscosity at a shear rate of 10/s is higher than the viscosity at a shear rate of 50/s. The coagulates of Comparative Examples A and B reveal higher viscosity values at higher shear rate, which is revealing dilatant behaviour.

Aqueous suspensions containing 3 wt% of potato protein coagulate of the samples were prepared and sheared for 2 minutes at 7000 rpm. The stirred suspensions were poured into 25 mL graduated cylinders and allowed to stand for 2 hours and 24 hours at which the sedimentation level and suspension levels were determined. The corresponding suspension volume index and sedimentation volume index were determined and tabulated in the Table below. The suspension volume index (mL/g) is calculated by taking the ratio of the suspension level in mL per liter and the concentration of the potato protein coagulate in the suspension in g per liter. The sedimentation volume index (mL/g) is calculated by taking the ratio of the sedimentation level in mL per liter and the concentration of the potato protein coagulate in the suspension in g per liter.

Table 3 Suspension volume index and sedimentation volume index

Example	Suspension volume index at 2 hours (mL/g)	Sedimentation volume index at 2 hours (mL/g)	Suspension volume index at 24 hours (mL/g)	Sedimentation volume index at 24 hours (mL/g)
2	32.7	0	32	0
3	13.3	0	32	5.3
A	2.7	2.7	3.3	3.3
B	3.3	3.3	3.3	3.3

Table 3 shows that the aqueous suspensions of Examples 2 and 3 have better suspension and sedimentation properties compared to the aqueous suspensions of Comparative Examples A and B.

Yoghurts comprising the potato protein coagulate of Examples 2 and 3 and Comparative Examples A and B were prepared according to the following recipe:

Yoghurt full fat (3% fat) ex Friesland Campina	140 g
Tap water	47 g
Sucrose	8 g
Protein coagulate	5 g

The yoghurts were prepared by the following steps:

1) weight in all ingredients
2) add sucrose and protein coagulate to yoghurt and stir for 10 minutes
3) add tap water and stir for 5 minutes
4) Store at 4-7°C; serve at 7-12°C

The resulting yoghurts were sensory evaluated by a trained panel of 13 people and scored on grittiness. The yoghurt comprising the potato protein coagulate of Examples 2 and 3 were not gritty and neutral in taste.

The yoghurt comprising the potato protein coagulate of Comparative Examples A and B were gritty.

CLAIMS

1. Potato protein coagulate which is pseudo-plastic.

2. Potato protein coagulate according to claim 1 wherein the ratio of the viscosity at a shear rate of 50/s and at a shear rate of 10/s is at most 1.

3. Potato protein coagulate according to any one of claims 1 and 2 having a viscosity of at least 2 mPa.s at a shear rate of 10/s and at 20°C when measured in an aqueous suspension comprising 5 wt% of the potato protein coagulate, based on the total weight of the aqueous suspension.

4. Potato protein coagulate according to any one of the preceding claims having a suspension volume index of at least 10 ml/g.

5. Potato protein coagulate according to any one of the preceding claims having a sedimentation volume index of at most 1 ml/g.

6. Potato protein coagulate according to any one of the preceding claims having a particle size distribution comprising a main peak and a second peak with the top of the second peak being at a smaller particle size than the top of the main peak.

7. Potato protein coagulate according to any one of the preceding claims having a d90 value of at most 50 μm, preferably having a d90 of at most 35 μm.

8. Potato protein coagulate according to any one of the preceding claims having a D[4,3] value of at most 50 μm, preferably having a D[4,3] of at most 35 μm.

9. Potato protein coagulate according to any one of the preceding claims comprising at most 150 ppm glycoalkaloids.

10. Potato protein coagulate according to any one of the preceding claims comprising at least 60 wt% protein, based on the total dry weight of the potato protein coagulate.

11. A food product comprising potato protein coagulate according to any one of the preceding claims.

12. Food product according to claim 5 wherein the product is a meat alternative, preferably a vegan burger.

13. Use of potato protein coagulate according to any one of claims 1 to 4 in food products.

14. Aqueous suspension comprising at least 1 wt% of the potato protein coagulate according to any one of the preceding claims.

15. Method of producing potato protein coagulate which is pseudo-plastic comprising the steps of:
    (a) providing a potato fruit juice comprising potato proteins;
    (b) optionally removing starch and fibers from the potato fruit juice;
    (c) optionally removing glycoalkaloids and/or phenolic compounds;
    (d) adjusting the pH of the potato fruit juice to a value between 4 and 5;
    (e) coagulating the potato protein at a temperature between 70 and 90°C to obtain a suspension comprising potato protein coagulate;
    (f) optionally removing glycoalkaloids and/or phenolic compounds;
    (g) optionally removing water from the suspension; and
    (h) optionally drying the potato protein coagulate.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065939

A. CLASSIFICATION OF SUBJECT MATTER

INV. A23J1/00 A23L19/12 A23L19/15 A23J3/14 A23L33/185
A23L19/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A23J A23L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/048873 A1 (LOTZ MARTIN [DE] ET AL) 25 February 2010 (2010-02-25) paragraphs [0032], [0076], [0078]; claims 1-11	1-15
X	WO 2016/133448 A1 (LYCKEBY STARCH AB [SE]) 25 August 2016 (2016-08-25) page 5, line 14 - line 16; claims 1-14; example 5 page 10, line 6 - line 16 page 14, line 7 - line 18	1-15
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A	paragraph [0024] - paragraphs [0027], [0042]; claims 1-19	12

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 August 2024	14/08/2024

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1

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065939

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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