Novel Potato Protein
New innovative protein process

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Denmark
Why a new method for producing potato protein?

Sharpened environmental demands have made it necessary for many domestic and foreign potato starch companies to consider alternative ways to utilize the potato fruit juice from the production of potato starch.

This has prompted Karup Kartoffelmelfabrik to arrive on the scene as a producer of high-quality protein who emphasizes environmental and energy considerations.

At Karup Kartoffelmelfabrik the primary production is potato starch and based on approx. 300,000 tons potatoes approx. 54,000 tons potato starch is produced and Karup Kartoffelmelfabrik is thus the largest potato starch factory in Denmark.

From this production a by-product named potato fruit juice is produced. This juice contains mostly water, salts, and protein. It has been known for years that based on nutritional experience this protein is one of the most wholesome and valuable proteins surpassed only by egg protein. Karup Kartoffelmelfabrik has
established a production to extract the potato protein in the most sustainable way in terms of the environment and use of resources.

With a grant from the EU Life scheme the factory has therefore developed a new sustainable method to extract refined protein that involves reduced energy and water consumption as well as reduced discharge of nutrients compared to the traditional method to extract protein. The new product, Novel Potato Protein, is comparable to other types of protein with regard to quality and properties.

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Now also for humans

Usually potato protein is primarily sold to the industrial community, but also to a limited extent as animal feed and it has previously been attempted to sell the protein for human purposes, but without success.

To extend the customer base, the factory has adopted a long term strategy of producing a protein with a low content of solanine (toxin) and with a light colour.

**Applicable for human purposes**

Solanine is a toxin produced in potatoes that have been exposed to sunlight. This can be seen as the potatoes turn green. Due to the solanine content, the protein cannot be used for human purposes.

The factory is therefore investing in a demonstration unit that makes it possible to extract a large percentage of the solanine and colour agent from the product to make it applicable for human purposes.

As a background for the new production, the production process will be described in the following for this way to give an impression of the product’s background from a process standpoint, its quality, etc.

Figure 3. Photo of the building including the demonstration plant.
Technological background

For implementation of a new production, a procedure has been adopted that involves literary research, visiting other protein factories, contacting equipment suppliers and experts in process technology and protein quality etc.

Based on these studies, research has been carried out on possible techniques for extraction of protein and optimization of the protein quality seen in relation to personal experience etc.

Main process items
The new concept involves the following main process items:
- Optimization of raw potato fruit juice containing protein by removal of foam, impurities, etc.
- Adjustment of potato fruit juice and protein precipitation by use of technically approved acid
- Preheating of fruit juice for gentle handling of the protein
- Heating of the protein
- Cooling the protein juice for energy recovery
- Holding-cell for precipitation of the protein
- Concentrating the protein fraction to minimize the drying expenses
- Drying the protein as gently as possible to obtain a uniform product
- Controlling and regulating the entire process to obtain the best result
The process for extraction of potato protein will be outlined in the following.

100 tons potatoes/hour,
As mentioned Karup Kartoffelmelfabrik is a producer of potato starch. Based on approx. 100 tons potatoes/hour, approx. 21 tons of starch/hour, 10 tons of pulp/hour and approx. 75 m³ potato juice/hour are produced and approx. 30-40 m³/hour of process water. In total including fruit juice and process water approx. 110-115 m³/hour are treated in the plant.

On the basis of the fruit juice a production potential exists of approx. 2.5 million kg for animal feed, approx. 2 million kg for refined animal feed and approx. 1 million kg high-value refined potato protein/hour per campaign.

Significant improvements
The new process will result in significant improvement in the quality of potato protein along with very big energy savings. Improvements in environmental conditions are also expected in comparison to today’s technology currently in use in the protein sector in Europe at the European potato starch factories.

The process can be seen from the flow sheet, figure 4, which describes each of the process steps. Figure 4 shows the production of potato starch and the new concept.
Applied technology in detail

Based on the abovementioned general description of the applied process the individual process steps are described in the following.

Optimization of raw potato fruit juice

In order to minimize colouring etc., the rasping processes for the potatoes take place in an oxygen free environment or by adding an anti-oxidant and/or by regulating the pH level. This is, among other things, done by applying an anti-oxidation agent directly to the raspers together with the potatoes. In this way, colouring of the protein called polyphenol oxidase, which happens in consequence of the brown colouring process, is avoided.

Furthermore, new process steps have been established in starch processing, allowing only a very low degree of re-circulation of the raw fruit juice or its residuals in the starch treatment process. This is done to avoid polyphenol oxidase.

Clean-out fine fibre and other impurities

To clean-out fine fibre particles in potato fruit juice (22 °C) hydrocyclones / separators with a capacity of 85 -100 m³/hour are used. The unit is specially designed and developed to separate particles from the liquid with a particle size of 0.5-500 µm and a volume content of suspended particles of 0.1 -10 % in the potato fruit juice.

The fixed suspended particles/fine fibres are collected in hydrocyclones/separator units, from where they are continuously crowded out and carried to a mounted refining cyclone. From here the separated fine-fibre, foam etc. is pumped to pulp-draining in the starch factory.

This way the fruit juice is cleaned of impurities and de-aerated, which benefits the protein and the following process steps significantly.

Figure 5. Separator and hydrocyclones.
Adjustment of potato fruit juice

pH adjustment of the potato starch is done with non-organic acid using a membrane pump for direct injection into the potato fruit juice.

When the pH level is adjusted to approx. pH 5, the proteins are impacted and will subsequently precipitate when heated (through denaturing of the protein).

The pH adjusted potato juice is then channeled to preheating via a tube.

The choice of pH value is based on recent lab testing, where the optimal level of precipitation has been established.

Preheating, heating and cooling of fruit juice

Preheating of fruit juice on spiral exchanger, step 1 / cooling recovery

The potato fruit juice is pre-heated from 22-70 °C with the help of a spiral exchanger of the type Alfa Laval.

This spiral exchanger is a fully-welded construction that differentiates itself by having a long channel duct, whereby precipitated protein maintains the same pace during the entire preheating session. At the same time the potato fruit juice is heated up slowly, which ensures a high uniform protein quality and also reduces potential precipitation in the exchanger due to pace.

The heating medium on the opposite side of the channel is heat recovered from the fruit water outlet that is cooled down. The pre-heated potato juice is then channelled via pipelines to a second pre-heating.

Preheating of fruit juice on spiral exchanger, step 2

Preheating the potato fruit juice from 70-100 °C also take place using a spiral exchanger of the type Alfa Laval and in principle the same procedure is used as described in the first step.

The preheated potato fruit juice is then channelled via pipelines to the third heating.
Heating of fruit juice using steam, step 3

The heating of the potato fruit juice is by direct steam injection.

The potato fruit juice is led through an inner tube, where steam is sprayed directly into the potato starch to a temperature of 100-115 °C.

The heated fruit juice is then led via a tube to a retaining cell. The choice of steam injector has been based on studies of what is the most gentle treatment of the protein.

Holding-cell for precipitation of the protein

A holding time of a few minutes is achieved by means of a holding cell. The cell has been made as a special tube spiral with a long pipe channel, whereby a uniform holding time and speed for the precipitated protein is achieved. The holding cell ensures a total protein precipitation of the coagulated proteins.

The potato fruit juice is then channelled to drain-off in a decanter via spiral exchanger.

Concentrating of protein

Draining-off/drying of potato fruit juice is done using a decanter type Alfa Laval, which is specially designed for the liquid/dry matter separation of hot liquid media.

The decanter is fitted with an adjustable shell plate system. In this system an extra decanter for removal of toxins, (TGA - total glyco alkaloids, as solanine etc.) using an acid feed system has also been installed. The system will also be used for precipitation of so called native protein (patatin) without heating in order to keep the functional properties.

The conveyor transporting the protein dry matter out of the decanter is made of special plough tiles, causing the momentum between the ball body and
Drying the protein

The drying of the protein takes place in an Ultra-flash-spin unit of the type CPS Powder System. It is specially designed for the factory.

The unique Ultra-flash-spin process dries the protein with minimal temperature damage using a drying process without back-mix (returning the protein), resulting in very low energy consumption.

The special air distributor and the very efficient disintegrator create a very big protein surface where the protein and the hot air come in optimal contact. This produces a very fast and strong evaporation of water from the protein. Then the protein is sent to a storage tank.

Controlling and regulating the entire process

The entire process is controlled and regulated with advanced monitoring equipment.

This way the biggest savings in resources and the best product are obtained. All deviations in the process or the product will be corrected within a few minutes.
Potato protein for new applications

To understand the factory’s interest in extraction of potato protein for new applications based on new and innovative processes, future possibilities have been described in short in the following.

In general it can be informed that potato protein is the most important nitrogen fraction in potatoes and that the content compared to the content of nitrogen is as high as approx. 75%.

The largest part of the proteins consists of very simple proteins. These can be classified into the following groups: Albumin (water soluble), globulin (soluble in saline solution), prolamine (alcohol soluble), and glutelin (soluble in diluted acid and base).

Another protein fraction is the proteides such as e.g. glyco proteides (patatin and lectin that are found in the cell walls).

2 characterizations

In literature the proteins in potatoes are described in different ways. In the following 2 ways/characterizations often used in literature will be described:

The largest potato protein fraction is usually called tuberine and accounts for approx. 70% of the protein content and this protein usually consists of both albumin and globulin. The protein fractions in potatoes are usually distributed as follows: 50% albumin, approx. 25% globulin, approx. 5% prolamine, approx. 10% glutelin and 10% other proteins.

In other and newer literature the content of protein is described as approx. 40-60% of the protein being categorized as glycoprotein that consist of patatin with a molecular weight of approx. 40 Kda and of another large group categorized as proteinase inhibitors (e.g. carboxypeptidase inhibitors and enterokinase inhibitors).

The content of proteinase inhibitors is estimated to make up approx. 40-60% with a molecular weight of approx. 22-30 Kda. The protein also contains so-called protein complexes with a content of approx. 10-20% and with a molecular weight of approx. 20-80 Kda.

Future applications

Many interesting fractions are thus found in the protein group in potatoes that can prove relevant in relation to future applications in the food industry and for medicinal applications.

Take e.g. patatin that can be used in many applications in the food industry due to its excellent functional properties or the proteinase inhibitors that are believed to be of value in the treatment of certain cancers and that already today are being used in the treatment of overweight (appetite reduction).

In addition there are enzymes (proteins) that can be used for special purposes in the food industry, e.g. preserving, stabilizing, etc.

Special varieties

In future increased work with variety breeding could consist of choosing special varieties with a high content of these protein fractions so they can be used in some of the mentioned applications. Additional exhaustive work with a survey (techniques, market) of these possibilities will continue at the factory.
General remarks & experiences

Based on the results from the last 3 years, the results have lived up to the expectations stated in the project’s application. These good results include the following test results from the first project year:

- Reduced energy consumption of 50-70% or more compared to traditional protein factories
- Reduction of nitrogen discharge by 50-60%
- Reduced water consumption of 50 - 70% compared to traditional protein factories
- Improved protein quality with lighter colour and a reduced content of glycoalkaloids (toxins).
- A valuable residual product – that is evaporated and can be used as a fertilizer in organic farming or as biomass for bio fuel - ethanol, etc.

Suppliers and cooperative partners
It can be informed that the primary and significant systems components for the novel demonstration plant have been developed, established and run in, in close cooperation with the following suppliers and cooperative partners:

- Alfa Laval Nordic, Denmark, +45 44 57 62 00 that together with the factory has developed and established systems components for purification of fruit juice, precipitation of protein and recovery of heat and for washing out the glycoalkaloids and precipitation of patatin, etc.
- Carlisle Process Systems A/S, Denmark, +45 44 34 99 25 that together with the factory has handled development, establishment and running in of the facility for drying the protein to a quality that over time will allow the protein to be used for human purposes.

The product development has further more taken place in close cooperation with scientific institutions, universities, etc.
For the novel process a DVD of the process has been made that is available by contacting the factory.
Environmental award

In connection with the established demonstration plant and the results achieved at the factory Karup Kartoffelmel- fabrik has been awarded Viborg County’s Environmental Award 2005.

The award is given to the company in Viborg County that has made the best effort for the environment. Viborg County’s purpose with the environmental award is to focus on companies that give environmental considerations high priority and work on minimizing the use of resources.

Figure 12. Environmental award. Mayor Bent Hansen presents Karup Factory’s Chairman of the Board Thorkild Sangild and Director Jens Mikkelsen with Viborg County’s environmental award.
Product declaration
Novel Potato Protein

Novel Potato Protein is a pure protein concentrate that derives from production of Superior potato starch. Due to its well-balanced amino acid composition, Novel Potato Protein provides excellent nutrients.

Characteristics
Appearance . . . . . . Light to light brownish powder
Water ......................................................... 11%
Protein (dry matter) ................................. 83%
Crude fat .................................................. 2%
Ash ......................................................... 2%
Solanine .................................................. < 125 ppm

You can use Novel Potato Protein as a substitute for other proteins such as milk and fish protein and for other vegetable proteins.

Amino acids
(percentage of total protein content - average values)
Lysine .................................................... 5.8
Methionine .............................................. 1.6
Cystine ................................................... 1.2
Tryptophane .......................................... 1.1
Valine ..................................................... 5.4

Novel Potato Protein is also an ideal ingredient in animal feed for mink and piglets.
Process and product information

Information including general project information, news pages, results, picture gallery, links, etc can be found on the following web site:
http://www.newpotatopro.dk

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At Karup Kartoffelmelfabrik in Denmark the primary production is potato starch based on approx. 300,000 tons potatoes. With a grant from the EU Life scheme the factory has developed a new sustainable method to extract refined protein that involves reduced energy and water consumption as well as reduced discharge of nutrients compared to the traditional method to extract protein. The new product, Novel Potato Protein, is comparable to other types of protein with regard to quality and properties.