

A blue tractor is harvesting sugar beets in a field. The tractor is moving from right to left, leaving a row of harvested beets behind it. The sky is overcast with grey clouds. The foreground is filled with rows of green sugar beet plants.

SUGAR UNION EXTRACTS PROTEIN FROM WASTE STREAM

**From worthless leaves
to valuable powder**



The Dutch sugar beet industry covers about 80,000 hectares. Each hectare of sugar beet produces about 20,000 kilos of leaves, of which the protein rubisco makes up one to two per cent.

After the sugar beet harvest, the leaves are usually left in the fields. That is set to change. In a demo factory, the sugar industry is processing the beet leaves into the protein rubisco, which can replace animal protein in foods.

TEXT ARNO VAN 'T HOOG PHOTO HOLLANDESE HOOGTE

At first sight, it looks like flour or milk powder, but the substance the Cosun factory in Dinteloord makes out of sugar beet leaves is practically pure rubisco, the enzyme that transports carbon dioxide in plants towards the photosynthesis process. Rubisco is not a household name, and yet it is the commonest protein in the world in terms of mass. Whenever you eat lettuce or spinach, half the protein on your plate is rubisco. In its pure form, it can be an interesting ingredient for use in protein foam, sauces and other food applications.

But first you need to get hold of a pure and economically viable form of rubisco. Besides protein, leaves consist largely of water, fibre and chlorophyll. It takes a lot of steps to turn the one to two per cent of rubisco they contain into a powder. On the factory floor in Dinteloord, in an area the size of two volleyball pitches, stands a shredder the height of a man, a press, centrifuges, membranes, columns and drying apparatus. This collection of stainless steel machinery was able to process 1500 kilos of sugar beet leaves per hour during the harvest period from September to December.

The process revolves around stripping the leaves step by step, removing the solid components, colour, smell and taste, says Paul Bussmann, senior researcher at Wageningen Food & Biobased Research. Bussmann started the research on developing rubisco purification 10 years ago, and has registered a patent for the refinery technology.

'You start by grinding up and pressing the sugar beet leaves, which gives you a juice that still contains tiny fibres and sand. The juice goes into a centrifuge and comes out as a clear, dark green liquid.' The green colour comes from the proteins with which the plant captures light. They react to heating by coagulating and then get left behind in a second centrifuge. The liquid that comes out, which contains the rubisco, is a light greenish-brown colour. 'That colour comes mainly from polyphenols, which make fruits and vegetables change colour when damaged. We remove them with membrane filters. After that the juice looks pure enough but the aftertaste is still green and extremely bitter.' The juice then flows through a porous column with a resin that the odour and flavour components stick to. And the last stage is drying it to form a protein powder.

FLAVOURLESS POWDER

Making rubisco powder odourless and flavourless is essential for using it in foods such as sweet foams, as an emulsifier in sauces or a binding agent in a veggie burger, says Bussmann. 'The steps in the refining process are not straightforward. We have detailed knowledge of the flavour components involved here and how you can remove them with resin columns. And for these kinds of technological developments you need to be able to bring together experts from different disciplines, such as protein and process technologists, project leaders and commercial types. Two PhD >



Sugar beet leaves are ground up and juiced.

research projects in Wageningen have also played an important role in developing the refining processes.”

EGG SUBSTITUTE

Rubisco can be a substitute for protein from hen’s eggs in many foods. Because no animal is involved, the powder has potential in the market for plant-based and vegan foods. Bussmann: ‘We know that rubisco performs very well in comparison with egg protein, whey protein and soya protein. That means you don’t need as much of it. So we don’t look so much at the powder’s nutritional value, because that is not what the industry pays for. Companies want to know: does it foam, does it gel, does it emulsify? If it does, the price shoots up by a factor of 10 or more.’

The demo factory in Dinteloord is the finishing line for now of years of development. It all began 10 years ago when Bussmann and his colleagues at TNO started extracting rubisco from algae and sugar beet leaves. The group transferred to Wageningen Food and Biobased Research two years ago. By then the researchers could already manually make a few kilos of pure rubisco out of hundreds of kilos of leaves.

The Dutch start-up Green Protein was interested in the patented process and with funding from a large French cooperative, a small pilot factory was built in Normandy

to process waste streams from large vegetable-processing companies. Bussmann: ‘You can isolate rubisco from the outer leaves of lettuces too. That factory processed 150 kilos of vegetable waste per hour. So we could do experiments to see whether it was worth scaling up. Sadly, the cooperative decided against continuing with a larger factory.’

EXCLUSIVE PATENT

Meanwhile, Green Protein had obtained exclusive patenting rights to the rubisco refining process, and at the end of 2018 the company was itself taken over by Suiker Unie, the Netherlands’ largest sugar beet processor. This company, part of the Royal Cosun cooperative, already processes other waste streams such as sugar beet pulp, and wants to develop alternative sources of protein too. The demo factory, which went into operation at the end of 2019, was built with the aid of a large European project grant of 4.2 million euros.

‘That EU grant is very important for research on the technical and economic feasibility, too,’ says Paulus Kusters, co-founder of Green Protein and nowadays senior protein programme manager at Cosun. ‘Half of the amount is being used to set up the factory and the other half for research. Such a big investment is often a stumbling block, whereas you really do need a demo factory on this scale to help you decide whether to build

a large commercial factory. You discover all sorts of things and you design things beforehand that then turn out differently to what you had in mind. In this phase you can make those mistakes and make improvements, because most of the apparatus is hired.’

BEET HARVEST

Another important purpose of the demo factory is to find out what the return on investment is. ‘You can lose some of your protein at every stage. That can only be studied on the factory floor, which is why we wanted to gather as much information as possible during the beet harvest over the four months up to just before Christmas,’ says Kusters. Although work in the demo factory went on around the clock in a three-shift system, and 1500 kilos of leaves were pressed per hour, this was still only a fraction of the total harvest of sugar beet leaves. Even a large-scale commercial rubisco factory could only process 5 to 10 per cent of the Dutch sugar beet leaves, reckons Kusters. About 20,000 kilos of leaves are produced from every hectare of sugar beet, and Dutch beet production covers about 80,000 hectares. Kusters: ‘The availability of sugar beet leaves is not a limiting factor for now.’

During the first practical test, the entire process was examined and developed. ‘We could only proceed to the next step of the refining process once the previous step was



PHOTOS SUIKER UNIE

The juice is purified, rid of colour, smell and flavour, and dried into protein powder.

‘Companies want to know: does it foam, does it gel, does it emulsify?’

stable. The goal for the first year was a stable process on this scale, and then the production of protein. Only in the final weeks of the sugar beet harvest did we run through the refining process from start to finish, and produce protein.’

REGISTRATION WITH THE EFSA

Those batches of rubisco are now being subjected to further research, explains Kusters. Their chemical composition and characteristics are being studied, as well as ways of processing them in demonstration products for food companies. The rubisco powder is also being used to put together a food safety dossier so it can be registered with the European Food Safety Authority (EFSA). This involved checking whether the powder can provoke allergic reactions and whether it contains any harmful substances. Rubisco is a natural protein isolate, says Kusters, but the EFSA looks at other issues as well. ‘You are refining a protein, and in

doing so you could end up concentrating other, undesirable substances. So you can’t say: rubisco powder is no different to leaf vegetables. The turnaround time for an EFSA dossier is a year or two. That is all part of the investment. The chances of it not being approved are very small, but the submission does affect when you can launch the product on the market.’

ENDIVE AND LETTUCE

The demo factory will not stand still for the eight months until the next sugar beet harvest begins. In that time, a number of summer crops are being experimentally processed into rubisco powder, says Kusters. ‘A commercial factory will not be able to operate at a profit if it is only open for four months a year. You need to be able to process crops and leaf waste almost all year round. We are going to run trials with vegetable crops such as endive and lettuce, and also with field crops such as certain

grasses, green fertilizers or alfalfa, a crop that is mainly used as livestock feed at present. We have screened a number of crops in the laboratory. Now that the factory is up and running anyway, we can test them on a bigger scale. It won’t be as extensive as the research on sugar beet leaves, but we can learn a lot from it as well.’

Given that rubisco only makes up a tiny percentage of the leaf mass, the process creates a lot of leaf waste at the factory. Currently, sugar beet leaves only stay behind in the fields, but the pressed leaf fibres could be used for livestock feed, says Kusters. And the liquid waste streams might contain other usable substances. ‘We will research that too. But for the first few years, we are focusing on the protein. That product has to be profitable to produce.’

At this point, Kusters cannot predict when the demo factory will have delivered enough information to make it feasible to upscale to a large-scale installation that can refine 15,000 kilos of leaves per hour. ‘That is affected by all sorts of commercial decisions about investments and estimates of the market for rubisco powder. Our ambition is to market a commercial rubisco product for food producers in 2022. Whether we’ll be talking about tons of powder straightaway should become clear in the course of next year.’ ■

<http://greenproteinproject.eu>