

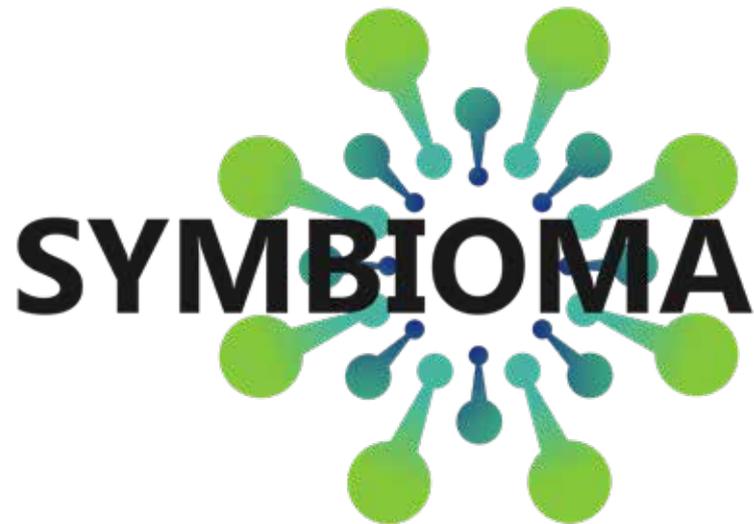


Northern Periphery and
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Technology Innovations and Business Models for Valorisation of Industrial Waste Biomass in Sparsely Located Enterprises

Circular economy cases and their business models in Norwegian potato industry

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1 Potato processing

Potato is one of the most important agricultural crops for human consumption and high amount is produced worldwide every year. In particular, the EU produced about 60.7 million tons of potatoes (FAOSTAT, 2020)¹. Potato peel is currently considered a zero-value or rather low value by-product, which occurs in large amounts after industrial potato processing and can range from 15 to 40% of initial product mass, depending on the various peeling or processing methods.

Food waste utilization causes great concern in food industry in Europe and many scientific works and projects on this topic offer solutions and original approaches towards possible valorisation of potato peels (Sepelev and Galoburda, 2015).²

Figure 1 represents a summary of the major wastes and by-products originating from the potatoes production and processing industry.

In Figure 2 is pictured a schematic process of potato processing and generated by-products with their most common current uses.

1 FAOSTAT 2020. FAOSTAT Crops. Available online: <http://www.fao.org/faostat/en/#home> (accessed on 9 January 2020).

2 Sepelev, I., & Galoburda, R. (2015). Industrial potato peel waste application in foodproduction: a review. Research for Rural Development, 1, 130-136.

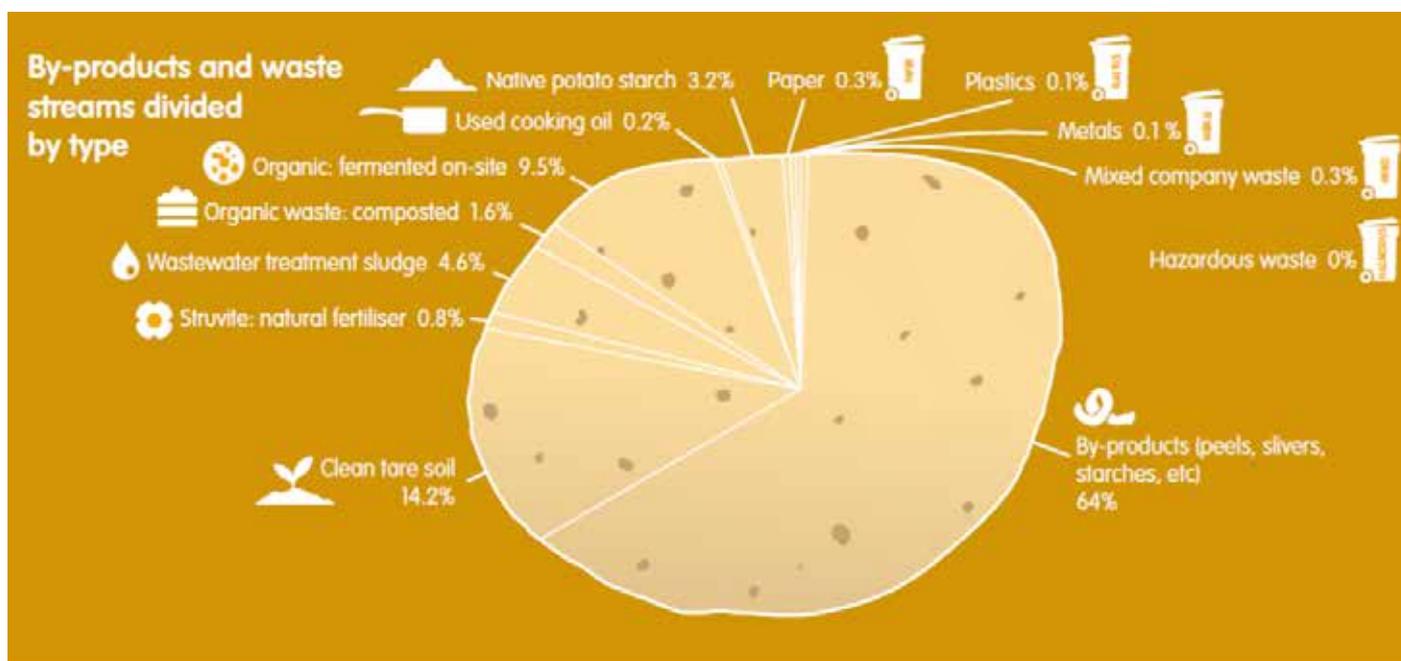


Figure 1. Schematic representation of the potato processing main wastes/by-products and the percentage composition of the different waste types (EUPPA, 2016).



POTATO PROCESSING AND GENERATED BY-PRODUCTS

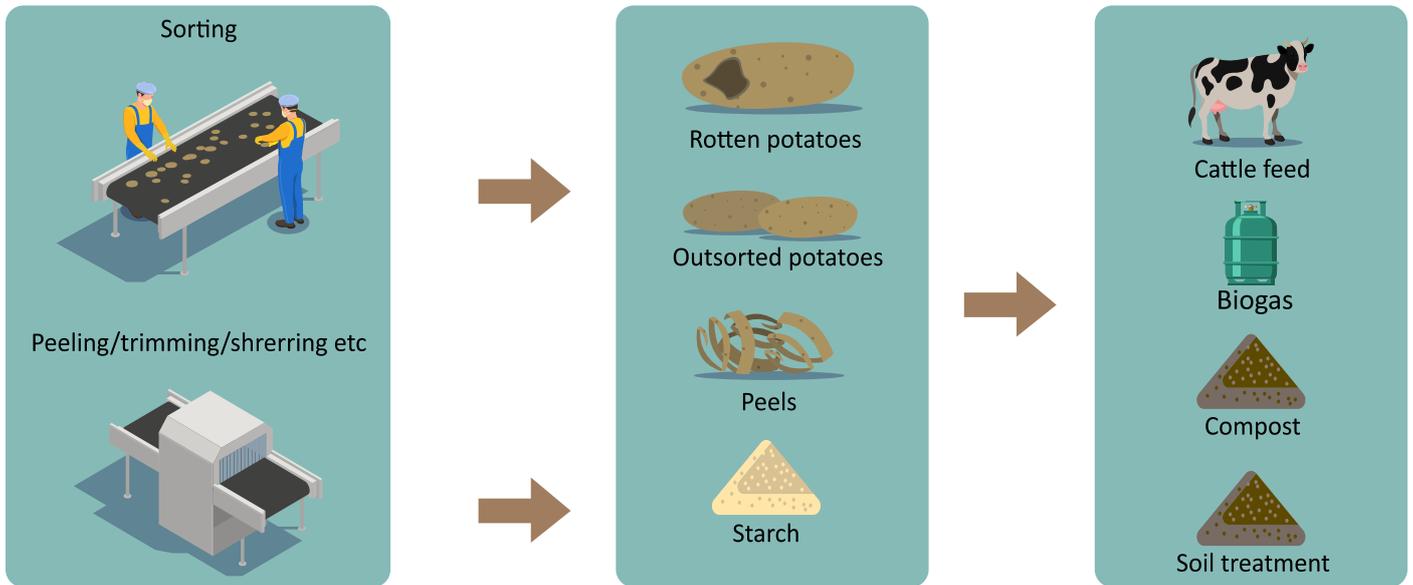


Figure 2 Schematic picture of potato processing and generated waste with it's common uses.

2 Potato industry and existing business models in Norway

Statistics Norway estimates that there are approximately 1 575 potato farmers in Norway, cultivating a total of 11 572 hectares, and producing 332 000 tons (SSB- Statistics Norway: Production of potatoes and forage plants, 2019). The total production of potatoes in the NPA region in 2019 was 71800 tons (SSB, www.ssb.no/jord-skog-jakt-og-fiskeri/statistikker/jordbruksavling/aar).

In June 2017, the Norwegian Government and actors from the domestic food industry signed an agreement towards a 50 % reduction of food waste in Norway by 2030. The agreement is signed by five ministries and 12 industry organizations, including the Norwegian Farmers' Association and the Norwegian Farmers' and Small Farmers' Association. Starting 2020, Statistics Norway (SSB) will gather and process all data related to food waste.

An important program in Norway is the "Reutilization of out-sorted potatoes" (Avrensordningen for poteter) that is under the Norwegian Agriculture Agency (Landbruksdirektoratet), an agency under the Norwegian Ministry of Agriculture and Food. The purpose of the program is to ensure the efficient disposal of Norwegian-produced out-sorted potatoes. Today 26 companies nationwide are

approved for selling their waste potatoes through this arrangement. Eight of these companies are located in the NPA region. The companies get into the arrangement through a three-year contract that stipulates the conditions for delivering waste potatoes. Yearly the contracted volume is about 45 000-50 000 tons waste, that includes waste potatoes, potato pieces, and starch water from potato processing.



Figure 3 Potato flour from Hoff. Photo Erling Fløystad, NIBIO.

However, the waste volume fluctuates from year to year depending on the yield and climatic conditions. The price is negotiated annually in the Agricultural Negotiations that take place between the Norwegian Ministry of Agriculture and Food and the two farmers' associations. The price depends on the dry matter content/starch content of the potatoes and this year it was notably increased.

This case is a very good example of circular economy utilizing the full potential of the whole potatoes. From the waste potatoes, they produce starch and alcohol, where about 20 000 tons goes into the alcohol production. The overall process is completed through Hoff, an agricultural cooperative owned by more than 500 potato farmers throughout Norway and producer of a wide range of potato food products. All the waste potatoes are transported to Hoff industries for further processing.

The starch is produced through a process of shredding and cleaning to retrieve the starch and then proceeds to a drying process to potato flour (see example in Figure 3).

Potato flour is utilized in a range of different food products such as minced meat or fish. Some of the flour is further processed to extract the glucose that is utilized both in candy production, as well as in pharmaceutical industries. The alcohol is processed through a similar initial process, freeing the starch from the waste potatoes, and then distilling it to rectified alcohol (96%). This alcohol is sold to various alcohol producers that use it as a base to produce aquavit, gin, or vodka. The waste material from processing starch or alcohol is utilized either as feed or as soil improvements.

We have identified four main categories of streams from the potato production: potatoes that satisfy criteria for human consumption and therefore proceed through different routes in the value chain to consumers, out-sorted potatoes that fail to meet the criteria of the first category and are mainly used as side stream products, potato peel that is utilized in side-streams, and rotten potatoes with limited utilization (Figure 4).

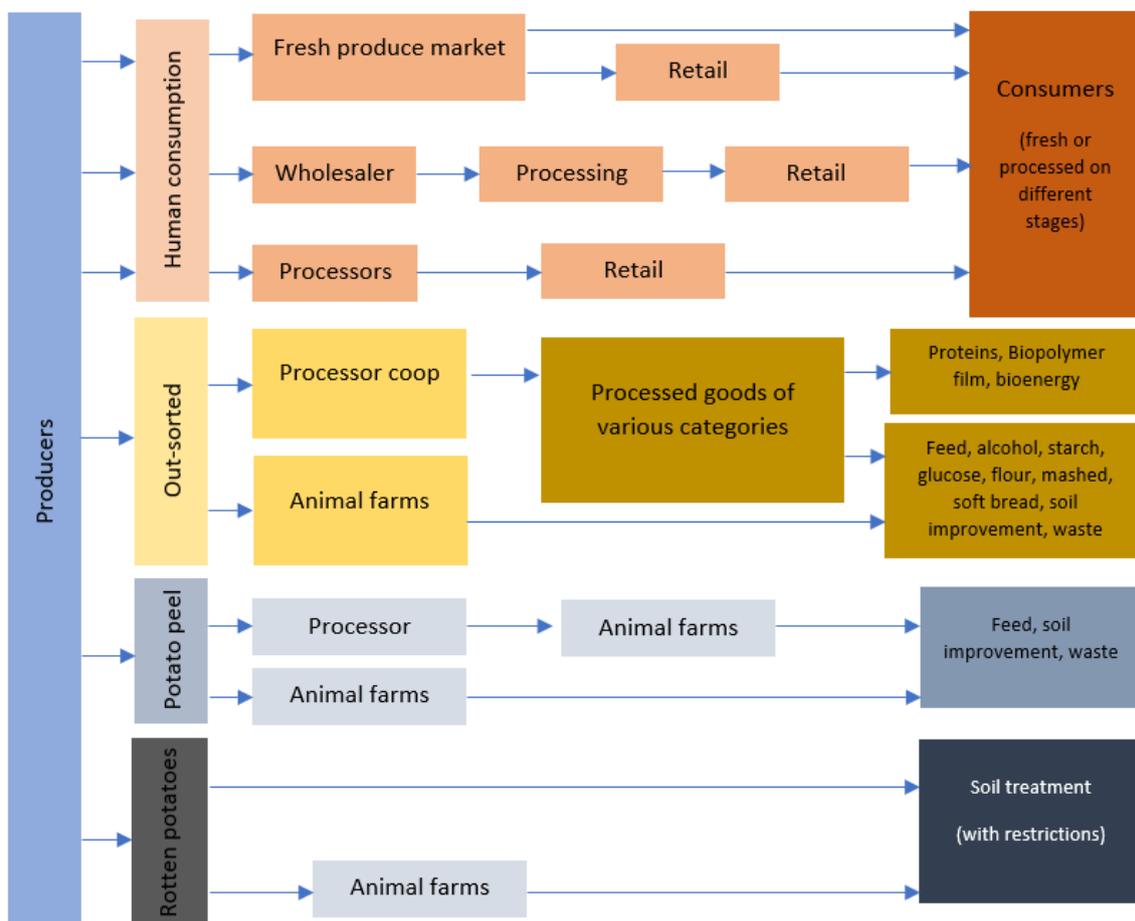


Figure 4 Value chain of potatoes in North Norway

Potatoes deemed for human consumption

Potatoes that satisfy the criteria for human consumption can either go to a wholesaler and then through processing, progress to retail and final consumption, or go for further processing before reaching the retail chains. In some cases, these potato volumes are sold directly from farmers in fresh produce markets (“farmers’ markets”), mainly locally.

Out sorted potatoes

The category refers to potatoes that have the wrong size, shape, either on the peel or internally. Potatoes are harvested, transported and in some cases stored, before sorting/grading. Storage in temperatures ranging from 12°C at inset to 4°C which is optimal. Storage can also increase the amount of outsorted potatoes. Water and some nutrients can be extracted as well as whole and cut potato segments.

Potato peel

Potato peel comes from potatoes that after harvest is sorted/graded before going into storage again. Before peeling, the potatoes are washed. The potato peel has a very high moisture content.

Rotten potatoes

Rotten potatoes are usually identified after harvest during sorting/grading, but rot can also develop during storage. Some of this waste end as compost, although there are several restrictions to utilize such compost due to a dangerous soil-borne potato disease (potato cyst nematodes).

Along the value chain we can identify several functions and processes that relate to different stages (Figure 5). Inputs relate to the pre-production stages and involve both domestic and international actors, as well as government bodies working on agricultural research and extension services. The production stage can vary depending on the farm and the potato variety, as well as weather variations. Processing also varies from case to case, while the trading stage that follows will segregate the production for the different markets and applications.

Additionally, there are different actors that get involved on the various stages of the value chain, ranging from local producers to nation-wide cooperatives as summarised in Table 1.

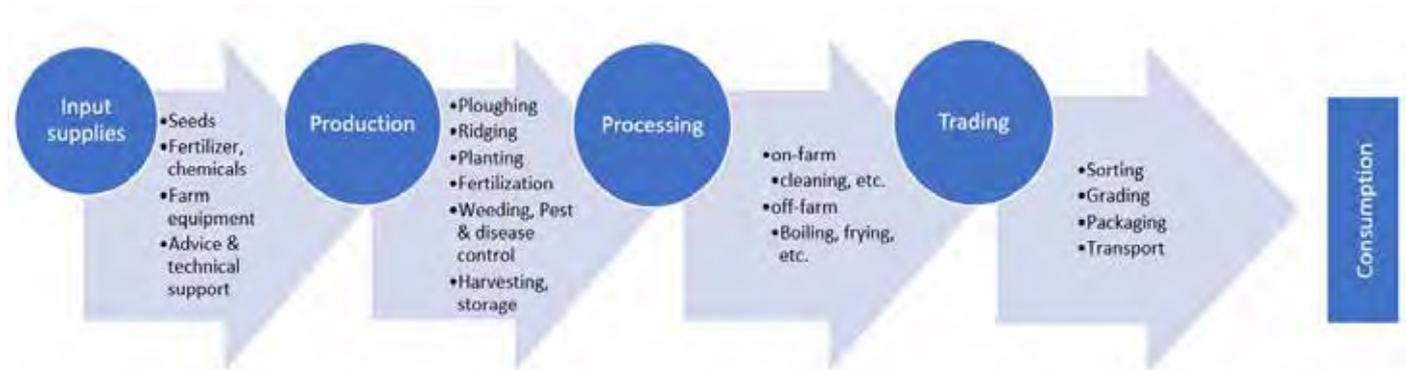


Figure 5 Functions and processes in the potato value chain

Function	Actors
Input supplies	<ul style="list-style-type: none"> • Cooperatives • Government institutions agriculture office (extension advise), research (seed), etc. • Farmers, farmers groups • Private companies
Production	<ul style="list-style-type: none"> • Smallholder farmers • Cooperatives
Proceccors	<ul style="list-style-type: none"> • Farmers • Wholesalers • Cooperatives
Grading	<ul style="list-style-type: none"> • Farmers • Collectors • Wholesale retailers
Consumption	<ul style="list-style-type: none"> • Locally • Retailers (supermarkets) • Institutional trade

Table 1 Main actors and functions in the potato value chain

2.1 Case 1: Potato wholesaler in northern Norway

The company is relatively large and is a farmer-owned receiver, storage, and packing facility for potato (and vegetables). The company is co-located with a processing facility producing various sous-vide processed potato products. Today's potato waste is: damaged potatoes, wrong size, shape etc. about 25% of total amount received approximately 1 125 tons potato, and potato peel, about 30-40% of the potatoes that are peeled, approximately 500 tons a year (peel and water). Current waste utilization is alcohol (through the "avrensordningen"), cow feed, soil improvement, and waste-deposition. The potential for improved waste utilization is considered high, especially in collaboration with other actors in the food industry.

2.2 Case 2: Potato producer 1 in northern Norway

A farm producing potatoes on 10 hectares. In addition, they have their own processing facilities where they are sorting, grading, washing, peeling, and packing mainly their own potatoes. Today they have about 5-10 tons peel and cut potato as waste from processing, and these are used as feed for dairy cows. Some of this, as well as some damaged potatoes, are used as compost for soil improvement. Small potatoes are used as seed potatoes. They see their best opportunities for added value from waste through cooperation with other food industry actors (fisheries), to increase the amount of biological waste. For instance, to utilize it to produce bioenergy.

2.3 Case 3: Potato producer 2 in northern Norway

A farm producing potatoes on 10 hectares. They have their own storage facility and a small-scale grading and packing facility. They are mainly selling all their yield, graded in bulk through a wholesaler. Currently all potato waste goes to compost and the farmer considers the potential for added value from the potato waste low. Small potatoes are used as seed potatoes. After shipping, the potato (and subsequent waste), is handled by the wholesaler.

2.4 Case 4: Potato producer 3 in northern Norway

A farm producing potatoes on 38 hectares. They have their own storage and grading facilities and are selling all the potatoes in bulk to a wholesaler. They estimate that they have about 240 tons of waste potato (in field and harvested). Current utilization is feed for own dairy cows or compost. Small potatoes are used as seed potatoes. The opportunity for added value is mainly through collaboration with other producers of biological waste to increase the volume.

3 Future opportunities for waste handling

- Direct sales of fresh and stored potatoes; less affected by strict quality requirements from wholesalers.
- Soil treatment/compost (but restrictions due to potato disease).
- Processing to get potato flour or other food products for human consumption.
- “Avrensordningen for poteter” opens the possibility for increased volumes on several raw materials for potato liquor, potato flour, and glucose.
- Collaboration with other food producers to increase the volume of biological waste processing to food, feed, chemical compounds, or energy.

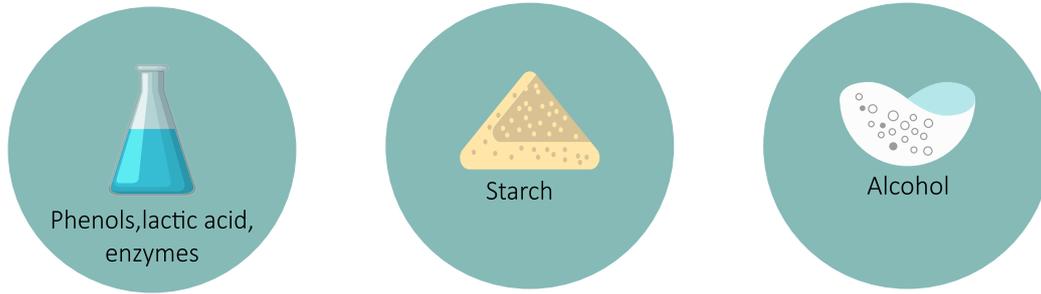
4 Bottlenecks / challenges for efficient waste handling

- Several restrictions due to possible spread of potato cyst nematodes (PCN), 1-mm long roundworms belonging to the genus *Globodera*. May spread with soil and infected machinery and equipment.
- Little collaboration / few common projects; leads to small waste volumes on each farm that lowers the potential for added value.
- Logistics; shelf life of perishable biological material.

POTATO BY-PRODUCT POSSIBILITIES



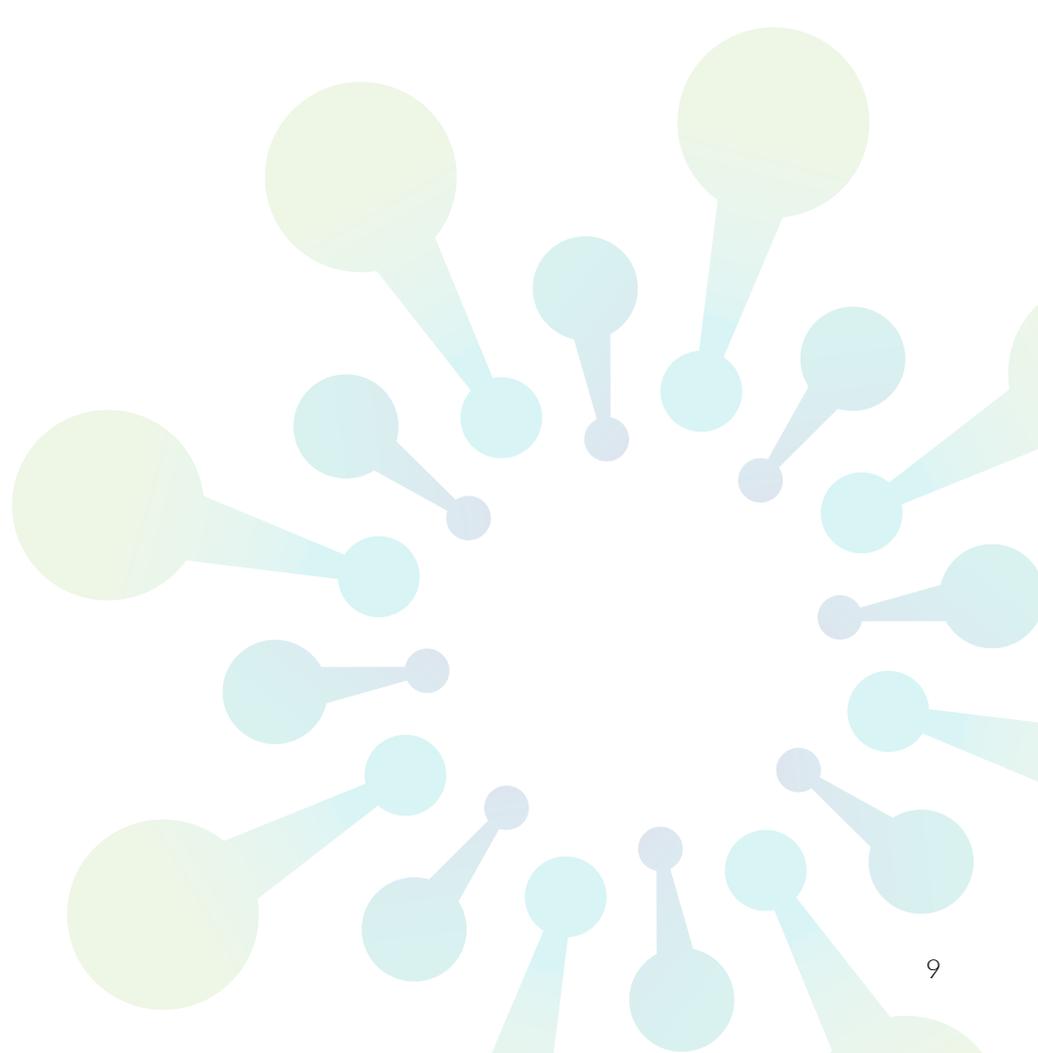
Example of valuables from by-products:



...that can be used e.g. in:



Figure 7 Possibilities of the potato industry by-products



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