Production and use of natural arabinogalactan polysaccharide for animal feeding

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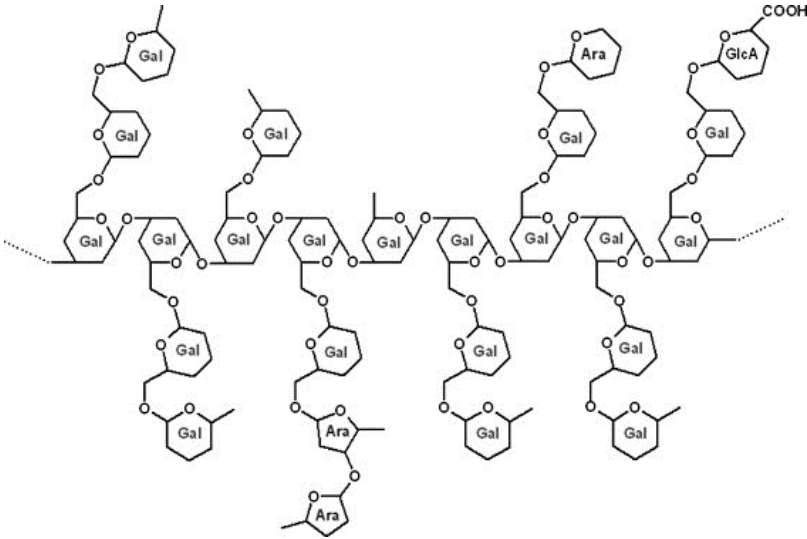
Arabinogalactan

Arabinogalactan is a water-soluble polysaccharide of plant origin, which has a variety of valuable properties (biological activity, surface-active and adhesive properties, good solubility in water, low viscosity of concentrated aqueous solutions), due to which it is used in medicine, food, pharmaceutical, cosmetic industry, veterinary medicine, as well as in the pulp and paper industry and printing



Uses of arabinogalactan

Medicine

- as an immunomodulator, in particular, for the correction of defects in the phagocytic system of an organism during pseudotuberculosis infection;

Pharmaceutical industry

- as a binder in the manufacture of tablets;
- to increase the absorption of drugs with low bioavailability.

Cosmetic industry

- in the manufacture of creams and masks as an emulsifier to stabilize oil emulsions;

Food industry - is used as a food additive E409 permitted in the territory of the Russian Federation (stabilizer)

- as a thickener in the manufacture of sauces, ketchups;
- as a dietary supplement for improving the activity of the gastrointestinal tract

In animals

Arabinogalactans isolated from Siberian larch are typical biologically active compounds (prebiotics) recognized as promising for use in medicine, pharmacology, and biotechnology.

In the United States, they are approved for use in food since 1974.

The use of larch arabinogalactan and taxifolin

Larch arabinogalactan and taxifolin have many uses and have been approved worldwide for human consumption and as a component of animal feed. About 1,000 tons per year are currently produced worldwide by Lonza and Ametis.

To become widely used in animal feed (to replace antibiotics), it needs to be produced cheaper. CelloFuel technologies make it possible to obtain arabinogalactan (LAG) and taxifolin (DHQ) from larch chips from larch cheaper than existing production technologies with higher purity from larch.

Larch arabinogalactan can eliminate the need for antibiotics in chicken feed, which allows you to sell chicken as organic (which gives a 50% price increase compared to chicken that is given antibiotics). In 2020, it will be prohibited to use antibiotics in feed for chickens in the EU and Russia, so larch arabinogalatan can be used in the EU and Russia to produce healthier chickens.

Carbohydrate-rich crops in Russia

Wheat 115 Mt / year, 78% starch	88.7 Mt / year
Corn 13 Mt / year, 15% starch	1.9 Mt / year
Sugar beet 47 Mt / year, 16% sucrose	7.5 Mt / year
Larch 129 Mt / year, 10% arabinogalactan	12.9 Mt / year

Larch growth in Russia: 24950 m3, 0.52 t / m3, 12974 Mt

Suppose you can collect 1% per year sustainably 129 Mt / year of larch

At a 10% content of arabinogalactan product 12.9 Mt / year

The problems of extracting arabinogalactan from larch

Problem: Trees grow deep in the forest, very expensive transportation
Solution: Remove the crude arabinogalactan near the logging area.

Problem: Arabinogalactan has a high molecular weight,
Solution: Extract by adding 5% ethanol to the chips, steaming

Problem: Energy is needed for steam and for drying crude arabinogalactan
Solution: Steam after burning wood chips after extraction of arabinogalactan

Problem: Logging area often moves
Solution: Put equipment in a shipping container, inexpensive

Problem

There are existing producers,
but the high price is an obstacle.

NanoTaiga and CelloFuel

The CelloFuel mobile biomass processing plant produces sugar from biomass. Our first project is the production of arabinogalactan from larch (LAG) and taxifolin (DHQ) from larch chips in the USA, Canada (tamarak), Russia and China (Siberian and Daurian larch). We also produce hemicellulose sugars from straw and coniferous wood, which can then be used to produce ethanol and animal feed.

No scale-up risk

The CelloFuel module is a single vertical HDPE pipe rotated around the center of gravity using a trunnion. Scaling to a larger scale involves simply increasing the number of modules and installing these modules where biomass is grown. We expect this to scale to tens of thousands of modules, so we are working hard to ensure that each module can be manufactured inexpensively.

Patent Status (on 15 November 2019)

There are four patent families for the production of sugars and ethanol that have been issued in the United States and around the world, including the United States, the EU, Canada, Russia, China, Mexico and Brazil.

Methods for fermenting carbohydrate-rich crops

- US9499839 (USA) status: Granted
- RU2642296 (Russia) status: Granted
- BR112016005352 (Brazil) status: Granted
- CN107109440B (China) status: Granted
- EP3140411 (European Union) status: Granted, validated in 10 EU countries
- AR106148A1 (Argentina) status: Pending
- Pending in India and Ukraine patent offices

Method for fermenting stalks of the Poaceae family

- US9631209 (USA) status: Granted
- RU2650870 (Russia) status: Granted
- EP3277825B1 (EU) status: Granted, validated in Spain, Italy, Hungary
- MX2017005160A (Mexico) status: Granted
- CN107849585B (China) status: Granted
- BR112017008075A2 (Brazil) status: Accelerated examination
- IN201717012771 filed with India Patent Office
- Accelerated examination in Ukraine patent office

Methods and apparatus for separating ethanol from fermented biomass

- US10087411 (USA) status: Granted
- RU2685209 (Russia) status: Granted
- CA3025016A1 (Canada) status: Accelerated examination
- CN109414627A (China) status: Accelerated examination
- Granted by Ukraine patent office
- IN201817037964 filed with India patent office (first examination report received)
- Accelerated examination in EU, Mexico and Brazil patent offices

Methods and systems for producing sugars from carbohydrate-rich substrates

- US9194012 (USA) status: Granted
- RU9194012 (Russia) status: Granted
- CA2884907 (Canada) status: Granted
- CN105283468 (China) status: Granted
- EP3004178 (European Union) status: Granted, validated in 7 EU countries

Existing technology

A known method (RU 2143437 C1), according to which arabinogalactan is extracted from crushed larch wood chips by water extraction at a temperature of 80-90 ° C in continuous circulation for 2 hours after removing from it dihydroquercetin (DHQ) with an organic solvent and drying the chips in a gentle mode. The aqueous extract of AG is concentrated under reduced pressure, treated with aqueous solutions of a coagulant — aluminum sulfate and Sunfloc flocculant, followed by filtration and precipitation of AG with a four-fold volume of ethyl alcohol, decantation of the supernatant, washing of the precipitate with alcohol and drying.

The disadvantages of this method are :

- high energy consumption for the concentration of the aqueous extract of AG by evaporation under reduced pressure;
- special storage conditions and a special mode of working with it;
- the use of a coagulant together with a flocculant, which increases the cost of the process and leads to contamination of the product.

Closest to the proposed is a method for producing arabinogalactan from larch wood, which consists in extracting larch wood with water for 1 h at a temperature of 95 ° C, filtering and centrifuging from fine solids, processing the extract with a polyamide sorbent in a turbulent mode, followed by filtration, and concentrating the filtrate ultrafiltration and isolation of the target product by spray drying (RU 2143437 C1).

This method has significant disadvantages :

- de-tarred larch wood is used to produce AG, which leads to the loss of an extremely valuable dihydroquercetin product and does not provide sufficient purity of the AG extract;
- multi-stage process and the use of expensive equipment (continuous centrifuges);
- the use of a powdered polyamide sorbent that requires frequent regeneration and does not have industrial production in Russia;
- the use of large quantities of methyl ethyl ketone, a toxic, flammable and expensive organic solvent, for the regeneration of a polyamide sorbent;
- low degree of concentration of the extract by ultrafiltration (AG content in the concentrate 10.5%).

Currently, there is no industrial production of arabinogalactan in Russia. In connection with the introduction of technology for the production of dihydroquercetin from larch wood, AG extract became a waste product and goes into wastewater.

Technology

CelloFuel technologies produce sugar and ethanol from biomass near the biomass growing area, eliminating the cost of transporting biomass to a more centralized location.

CelloFuel technologies can be scaled to industrial sizes, but they are equally effective on a farm scale. Our initial product is a large-scale product that scales by parallel replication to hundreds of modules.

CelloFuel modules inject reagents into sugar-rich raw materials, optionally depolymerizing lignin, optionally depolymerizing hemicellulose, and extracting polymer and monomeric sugars using semi-continuous counterflow extraction.

CelloFuel modules can optionally be assembled in a series of 4 to 8 modules for semi-serial countercurrent sugar recovery. Each module uses a patented vacuum cycle with enzymatic hydrolysis to accelerate the extraction of sugars from biomass into bulk liquid.

CelloFuel modules can optionally ferment monomeric sugars to ethanol within biomass. CelloFuel modules produce aqueous ethanol with an alcohol content of 80 to 95% by volume (ABV). It can be used for the production of drinking ethanol, fuel for engines and fuel for cooking. This aqueous ethanol can be transported to a central refinery for the further production of transport fuels or more valuable chemicals.

Manufacturing

The CelloFuel Portable Biomass Processing Plant is made up of several CelloFuel modules, each made of a vertical HDPE pipe. Pipes are loaded by rotating the pipe around its center of gravity on the trunnion. Pipe rotation is used for loading and unloading biomass.

CelloFuel modules are low-cost vacuum containers that use food grade HDPE and stainless steel. They can be quickly collected near the biomass collection site.

The CelloFuel module is designed for very cheap production and can be assembled and disassembled with a hand tool - a screwdriver and a wrench. Low-cost gasket is used to seal end caps with HDPE corrugated pipe. For the manufacture of end caps, the central belt and the trunnion, some metal cutting, metal rolling and a little welding are required, everything else can be done with a metal saw and drill. The axle does not need a bearing. When disassembling, several CelloFuel modules can be transported efficiently in 20-foot shipping containers.

The top and bottom of the HDPE pipe are connected using stainless steel plates. When using oxalic acid with softwood, they are made of type 444 stainless steel, which is resistant to corrosion with oxalic acid (like HDPE). The top cover has a cover that can be removed from the HDPE pipe to load and unload biomass. Several HDPE pipes are mounted in rows so that they can be efficiently loaded and unloaded and used for semi-continuous counterflow extraction.

Project Status (15 November 2019)

We are testing to optimize the extraction of arabinogalactan from larch chips. We use US Pat. No. 10,087,411 with a 75 mm diameter vacuum distillation column to optimize this process. As soon as this is done, we will begin to test a vacuum distillation column with a volume of 2.5 m3.

Pilot

A 1/3 scale model of the CelloFuel module was successfully built, and we are starting to create a full-size CelloFuel module with a diameter of 1 m and a height of 6 m (with an assembly cost of less than $ 2,000). The 1/3 scale model has a volume of 1/2 m3, where the full-size CelloFuel module is 5 m3. Here are some pictures of vertical orientation, horizontal orientation, top cover and trunnion.

NanoTaiga

For more information

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