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FORSCHUNGSFORUM
1/2005

CASCADING OF RENEWABLES

AUSTRIAN RESEARCH ON THE CASCADING USE OF RENEWABLE RAW MATERIALS FOR THE "FACTORY OF TOMORROW"

granulating

separating

skinning

drying

crushing

fermenting

grinding

distilling

bmvit
Austrian Federal Ministry for Transport, Innovation and Technology

RESEARCH PROJECTS ON THE CASCADING USE OF RENEWABLES FOR THE "FACTORY OF TOMORROW"

FABRIK der Zukunft

In 1999, the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) launched the "Austrian Program on Technologies for Sustainable Development", which effectively supports future-oriented modes of economy through research. Various research and development projects as well as demonstration and diffusion measures, which give new impetus to innovation in Austria's economy have since been supported within the scope of a number of subprograms.

The "Factory of Tomorrow" subprogram aims to encourage trend-setting pilot projects in the field of sustainable technology development. Model examples include innovative manufacturing processes, future-oriented products or exemplary enterprises. Innovative development should focus primarily on the fields "technologies and innovation in production processes", "use of renewable raw materials", and "products and services". The "Factory of Tomorrow" subprogram is being financed from the Federal government's special funds for technology development on recommendation of the Council for Research and Technology.

■ Recycling of renewable raw materials is increasingly becoming a crucial factor for sustainable development. Renewables will be the basis for the industrial production of novel materials, chemicals, and product ranges. Many cultivated plants contain skeletal and storage substances that can be used in industrial processes as well as bioactive substances, which could replace some industrial chemicals that had to be extracted from fossil raw materials in conventional processes. Examples include natural dyes from plants extracts, biodegradable foils from starch, insulating materials from plant fibers, biopolymers from lactic acid, lubricants and asphalt from plant oil as well as substances for phyto-pharmaceutical and phyto-cosmetic products, and food additives from domestic plants.

Products from renewable raw materials are already commercially competitive compared to synthetic products. However, there still is great need for further research concerning particular functional characteristics and the various potential uses of domestic renewables.

An important topic deals with the **cascading** use of renewables in regional networks. Cascading refers to the intensive multi-functional use of materials, i.e. the potential of a given raw material to provide various different services in a sequence of different uses. The design of new products from domestic renewable raw materials and the recycling of waste material from agriculture, respectively, constitute important focal points of research and development, which could open up new opportunities for many regions and enterprises in Austria.

Developing promising uses for plants and plant residues requires close cooperation between researchers and regional businesses as well as networking between the various actors from agriculture, the industries and trades involved, tourism and the health services. The goal of these cooperation projects consists in developing new lines of business and branches of industry and, in doing so, creating new jobs and contributing to a stronger Austrian economy.

The projects below originated within the scope of the "Factory of Tomorrow" subprogram and aimed to analyze potential uses for domestic renewables; in cooperation with enterprises in the region, they also developed concrete models for implementation.

PROJECT 1

NAWARO-Cascading für die Wellness-Regio und Folgeprojekte (Cascading of Renewables for the „Wellness Regio" and Follow-Up Projects)

Project Partners: Dipl.Chem. Univ.-Lektor Hanswerner Mackwitz and Dr. Wolfgang Stadlbauer (alchemia-nova, Institut für innovative Pflanzenforschung, www.alchemia-nova.net); Ing. Elmar Wimmer (e+c engineering & consulting); Vienna 2003

This project investigated possible cascading uses of stone fruit residues in food and non-food applications; in addition, the researchers developed a multitude of concrete options of using the stones of cherry, apricot, peach, and prune as materials as well as the fine chemicals contained in the kernels; these options could be implemented and established as commercial products on the market by participating enterprises.

PROJECT 2

Gewinnung von adsorptiven Produkten aus Maisreststoffen (Extraction of Adsorptive Products from Corn Residues)

Project Partners: DI Dr. Christian Krotscheck, Mag. Regina Nievoll, DI Dr. Stefan Kromus (Kornberg Institut für nachhaltige Regionalentwicklung und angewandte Forschung, Steirisches Vulkanland Regionalentwicklung GmbH); Feldbach 2003

This project aimed to develop and test a technology that permits to manufacture products with adsorptive characteristics from corncobs, which remain as by-products when harvesting grain corn (maize).

CASCADING OF RENEWABLES FOR THE "WELLNESS REGIO"

Investigation of possible uses of stone fruit residue matter in food and non-food applications

The cultivation of fruits, in particular stone fruits is a hallmark of some regions in Austria. Thus, the Wachau region has been famous for the cultivation and processing of apricots for generations while the province of Styria has been growing different varieties of prune, cherry, apricot, and peach. Concerning stone fruits, however, use has been restricted to the fresh fruit and the processing of the fruit pulp and the juice to yield a whole range of products such as jam, jellies, juice or selected spirits. So far, the stones have not been used; they are considered undesirable waste, which has to be dried and then burned or tipped some place where it is left to rot down eventually.

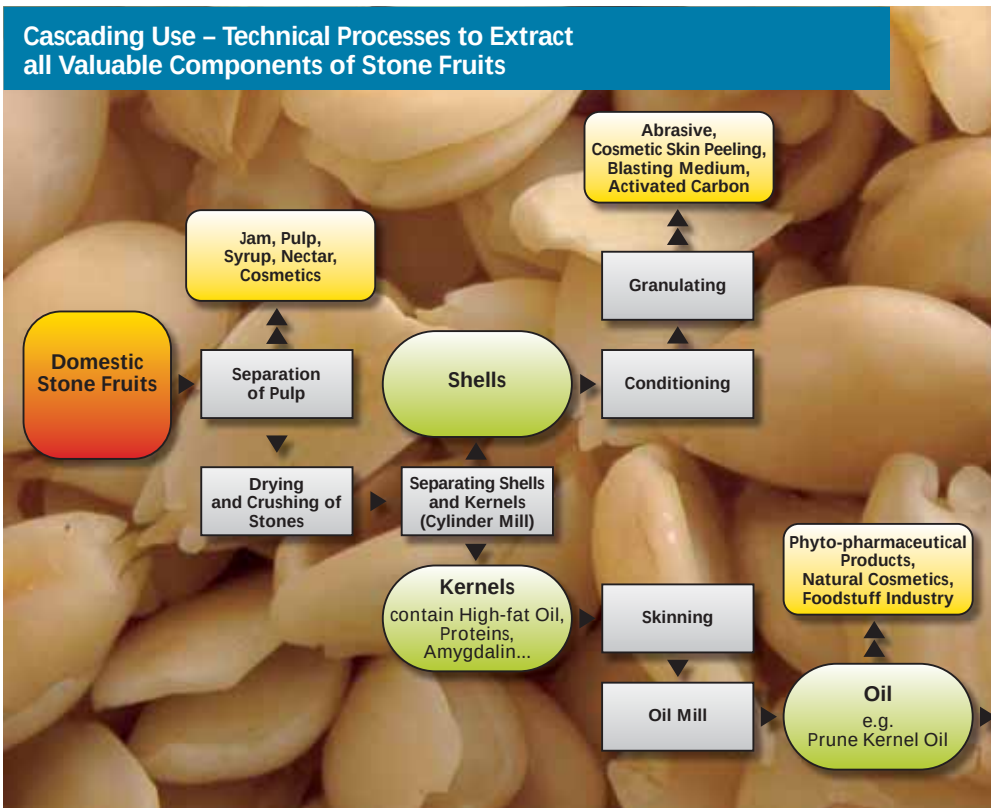
The **"Cascading of Renewables for the Wellness-Regio"** project aimed to ascertain options of recycling agricultural by-products using the example of fruit stones. The development of material cascades for agricultural products, especially for plant residues constitutes a promising potential, which has remained unused to date. In order to avoid a situation where huge quantities of fruit stones are simply wasted and in order to make use of the valuable substances contained in these by-products we have to develop sustainable technical solutions for the manufacture of by-products that make the multi-functionality of stone fruits available for use.

Special consideration has been given to the use of the fine chemicals and to the functional characteristics with a view to the generation of added value in fields as different as cake, pastry, and foodstuff production, cosmetics, wellness, and materials engineering. The thermal spring region ("Wellness Regio") in the southern part of Styria was taken as a test field where researchers, in ***close cooperation with partners in this area*** aimed to develop sustainable options of using the fruit stones in order to broaden the range of products from this region, thus creating additional sources of income.

Basic research used a series of practical experiments to test and identify suitable methods for the processing of fruit stones. The moisture content of the kernels ranges from 87 to 90%, they are soiled and are liable to perish through fermentation and mold formation. Pre-drying is therefore imperative before any further processing. The fruit stone consists of a hard outer shell and a soft kernel, which is covered by a thin pellicle (skin). In order to be able to make use of all valuable components it is necessary to apply special technical processes to separate shell and kernel and, subsequently, mill the kernel. Researchers and project partners cooperated in testing gentle methods for these process stages; these methods will be further developed in a follow-up project to facilitate implementation on a larger scale. In addition, laboratory tests were carried out to find suitable methods of oil pressing.

Fruit stones, oils and the mill cake were examined in detail with regard to individual components and possible uses. The kernels were analyzed for proteins, fat, carbohydrates, pattern of fatty acids, volatile compounds, the vitamins

Cascading Use – Technical Processes to Extract all Valuable Components of Stone Fruits



Source: Concerned People GmbH

Participating enterprises

- *Gölles, fruit distillery and vinegar manufacturer, Riegersburg/Styria*
- *Ferschli, fruit distillery and liqueur manufacturer, Krobotek/Burgenland*
- *Zotter, chocolate manufacturer, Riegersburg/Styria*
- *Ölmühle Fandler, oil mill, Pöllau/Styria*
- *Ringana Frischekosmetik, natural cosmetics, Hartberg/Styria*
- *Sonnenblumenpark, sun flowers, Tulbing/Lower Austria*
- *Steirische Beerenobst reg.Gen.mbH., Lieboch/Styria*
- *Hans Staud, jams and vegetable delicatessen, Vienna/Austria*

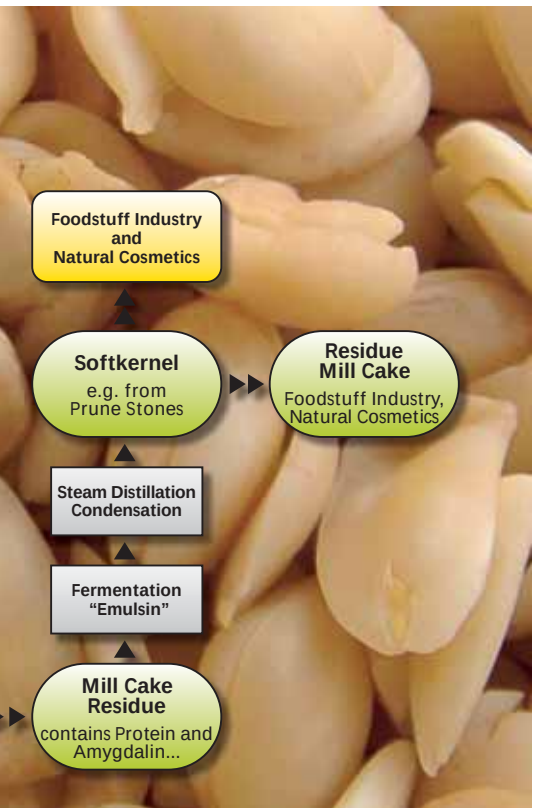


A and E. Analysis of the different oils and the mill cake ascertained fatty acid patterns and cyanide content; the mill cake was, in addition, analyzed for proteins, fat, and carbohydrates.

The basic research resulted in a multitude of concrete options for different uses of the various components of fruit stones:

- **Stone fruit kernels as delicatessen**

Both, the soft kernels, with or without the skin, are suitable for use in the foodstuff industry. Tests have shown that they can be used in the manufacture of various products such as sweet brittle, nougat, marzipan varieties such as persipan, prunipan, cherrypan, apricopan as well as combinations with



chocolate, bakery, and muesli bars. The Styria/Burgenland region is particularly famous for its prunes, and some manufacturers favor the stones of these fruits. The kernels are soft, have a slightly bitter flavour; they go well with cardamom and star anise.

Native oils pressed from kernels can be used as fresh product in a more refined cuisine and in restaurants. Each oil variety has a specific flavor and thus could be easily positioned on the market. Oil from prune and cherry kernels seem to be particularly promising.

- **Cosmetics applications**

The project has shown that the oils and the mill cake can also be used as valuable components in the manufacture of natural cosmetics.
High-fat oils serve as a basis for bath and massage oils, for creams, balsams, and shampoos. They can be easily mixed with essential oils and contain additional active care substances.
Prune kernel oil (preferably from organic cultures) seems to have the greatest potential, followed by cherry, apricot, and peach.

In addition, kernel and mill cake powder can be used as thickener or as part of the emulsifier system of cosmetics. Because of its physical characteristics, finely ground granulated material from the outer shell is also suitable for the manufacture of ecologically and dermatologically valuable peeling products.

- **Stone fruit shells as blasting medium or auxiliary material**

Another potential use for stone fruit residue consists in applying the shell fraction as soft-acting blasting medium in the automotive industry and in aircraft and space technology. Grinding the shell fraction to ultra-fine particles makes them also suitable as filler for polymers.

Investigations and R & D work have highlighted various concrete uses for fruit stones; now; enterprises in the regions have the opportunity to make use of the results. However, the concrete implementation of specific applications requires further research, upscaling and demonstration projects.

The most important objectives of further R&D activities include:

- Improving the crushing and separating technologies
  At present, there is no specially adapted crushing and skinning technology that meets the specific requirements of domestic fruit stones.
- Optimization of oil extraction
  This point focuses on the development of alternative extraction methods and further analyses concerning the chemical structure of the various types of oil.
- Establishing the kernels as a delicatessen
  Close cooperation with enterprises such as the chocolate maker Zotter and other SMEs is a promising approach in this context.
- Developing an innovative range of natural cosmetic products
  Here, cooperation with a partner from the trade is to develop a customized range of wellness products (e.g. peelings and vitalizing packs from the residues of blasting media production and oil pressing).
- Developing a business plan

"NAWARO CASCADING PILOT", the follow-up project currently conducted within the "Factory of Tomorrow" subprogram aims to develop a plant technology and business plan for the installation of a pilot plant for fruit stone processing in Austria.
(> see backside)

PROJECT 2

EXTRACTION OF ADSORPTIVE PRODUCTS FROM CORN RESIDUES

Corn (maize) is an important crop, which is grown in many regions in Austria. In addition to the starch containing corn grains, the plant consists of other parts, which could be used as renewable raw material in industrial recycling processes. The residues (leaves, stalks, and cobs), which usually are left on the field, constitute a highly interesting potential with a view to quality and quantity. In the province of Styria alone, for instance, 500,000 tons of corn residues remained unused on the fields in the year 2000.

The project **"Extraction of Adsorptive Products from Corn Residues"** conducted jointly by *Kornberg Institut* and its partner *Biodiesel international Anlagenbau GmbH* aims to investigate various methods for the use of corn cobs. Three possible products based on ground corn cobs are being analyzed in detail. The three potential products were selected with a view to simple processing, good chances for marketing, and significant ecological benefit of the final product.

Investigations concentrated on adsorptive products from corn residues for the applications below:

- Application as oil binder on solid ground in disaster prevention and for environmental protection measures; clean up of contaminated soil
- Application as oil binder for water bodies, also in disaster prevention and for environmental protection measures
- Use as hygienic product for pets (e.g. cat litter etc.)

The project was conducted in two phases. The **process development phase** prepared a technical concept for a corn cob processing plant for the conditioning, grinding, and mechanical separation of the different fractions and implemented the concept in a pilot plant. This phase also included laboratory analyses to identify the most important parameters of the corn products. Analyses investigated the adsorptive capacity for oil and other contaminants as a function of grain size and moisture content of the material and ascertained the optimum grain size for oil separation in aqueous applications.

In the **product testing phase** a sufficient quantity of corn granules was produced in the pilot plant to facilitate a detailed analysis of the product characteristics. In addition to testing the efficiency and quality of the granules, researchers investigated methods of optimal disposal in this phase. Intensive cooperation with potential users served to incorporate practical experience in the investigations.

The tests confirmed the exceptional structural quality of corn cobs concerning their adsorptive capacity. Researchers developed an economically viable process and implemented it in a pilot plant; this will facilitate the manufacture of marketable products from corn granules for various applications.

Practical tests have shown that the efficiency of adsorptive corn granular material as oil binder on solid ground in disaster prevention and for environmental protection measures as well as

for the clean-up of contaminated soils is good; efficiency as hygienic material for animals has been shown to be very good (adsorptive capacity was 0.7 to 0.9 kg oil per kg of granular material and 1.0 to 1.3 kg water per kg of granular material). The product can, however, not be used as oil binder on water surfaces because it does not meet the requirements regarding buoyancy.

Concerning economy, tests have shown that the combined production of oil binder and hygienic material by means of a cutting mill and a separating plant for the crucial process stages is the most profitable option. In the case of a decentralized plant with an annual output of 3,000 tons and a high rate of utilization the price ex factory has to be above 60 cent per kg for oil binder material and above 30 cent per kg for hygienic material. These prices can be attained on the market. Thus, the utilization of corn residues opens up new market opportunities for innovative agricultural enterprises; it should be possible to create additional income amounting to plus 22% compared to the income from the marketing of corn grain alone.

The technology used for the manufacture of oil binders and animal hygienic material could be used as a basis for other innovative uses of corn residues. Follow-up projects should be initiated to investigate other promising applications (e.g. solid matter fermentation of stalks and leaves or other special applications for the corn cob granular material).

P R A C T I C E

NAWARO-CASCADING PILOT

■ Closely cooperating with enterprises and experts, researchers in this follow-up project aim to establish methods that permit to make the use of residues from stone fruit processing more professional. The goal consists in establishing the basics for the installation of a pilot plant in Austria that permits to transform fruit stones into a marketable product.

The first step in the implementation of the demonstration project will require designing a suitable washing and drying unit for the fruit stones. Operation of this plant should use up as little energy and resources as possible.

The pilot plant should be designed in such a way that it can process the different varieties and sizes of the raw material (stones of cherry, apricot, peach, and prunes). The units for the individual process stages (crushing of the stones, cleaning, skinning, sieving) will consist of flexible modules. All final products have to meet the highest quality requirements. This applies, both, to the micro-particles of blasting media and the soft kernels, which should be free of impurities and intact. The standard required for foodstuffs can be attained by means of special sorting machines, which use ultra-sound and / or laser technologies.

The objective of the project consists in defining the design, sizing, dimensions and the operational parameters of the planned pilot plant, to identify a location suited with a view to logistics, to ascertain the necessary investment costs, and to prepare a business plan.

In the course of development work done so far, it became clear that the planned capacity of 50 to 70 tons of fruit stones per year was insufficient. In order to be economically viable the plant should have an annual throughput of at least 250 to 300 tons. Researchers and various partners are currently cooperating in the planning and realization of such a plant.

F I G U R E S / D A T A / F A C T S

PROJECT PARTNERS

All Projects were conducted within the scope of the “Factory of Tomorrow” subprogram.

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Project partners:
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Feldbach 2003

INFORMATION PUBLICATIONS

The final reports on the abovementioned studies have been published in issues 18/2003 and 22/2003 of the bmvit series “Reports on Energy and Environment Research” and are available from: www.NachhaltigWirtschaften.at

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FORSCHUNGSFORUM *provides information on selected projects within a bmvit program focusing on “Sustainable Economy”. Published by the Austrian Federal Ministry for Transport, Innovation and Technology (bmvit); Division for Energy and Environment Technologies; Director: Dipl. Ing. M. Paula; Renngasse 5, A-1010 Vienna, Austria; Photos and diagrams: H.W. Mackwitz, Concerned People, C. Krotschek, Kornberg Institut, Projektfabrik. Editors: Projektfabrik, Nedergasse 23, A-1190 Vienna, Austria. Layout: Grafik Design Wolfgang Bledl. Printed by: AV+Astoria Druckzentrum GmbH, Faradaygasse 6, A-1030 Vienna, Austria.*

FORSCHUNGSFORUM is published four times a year and is available for free from: Projektfabrik, A-1190 Vienna, Nedergasse 23, versand@projektfabrik.at

P.b.b. Erscheinungsort Wien, Verlagspostamt A-1010 Wien.