Natural resources and
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Conference on

Non-Timber Forest Products and Bioeconomy

28–30 November 2017, Rovaniemi, Finland

Rainer Peltola (ed.)

Luke
NATURAL RESOURCES
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Abstracts

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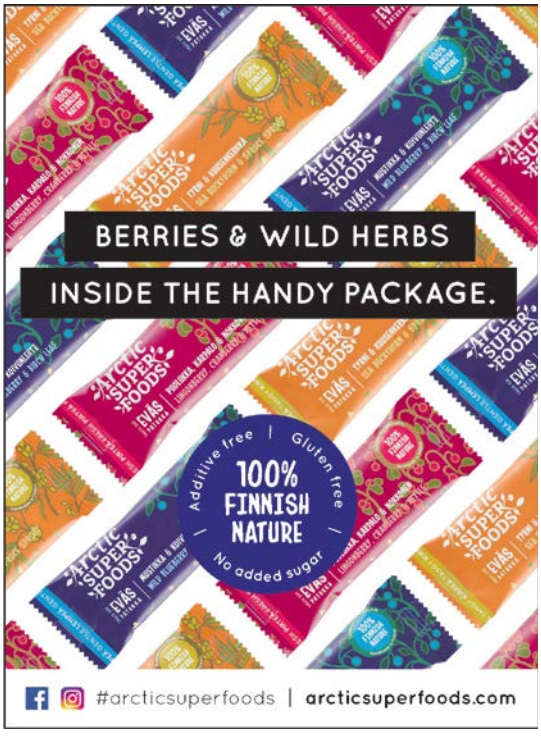

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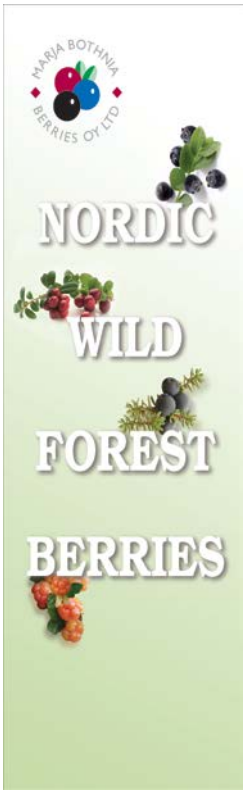

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Welcome to the NTFP2017 - conference

Non-Timber Forest Products – NTFPs, natural products or wild forest products – are raw materials which have long history as food ingredients, pharmaceuticals, fibers and decorative materials. NTFPs have always had an important role in economies which have depended on forest resources.

Modern era has brought many challenges to forest sector. Utilization of forest ecosystem services have often concentrated to provision of timber, but the emergence of bioeconomy concept has broadened our approaches to forest resources. Versatile use of forests is in the core of bioeconomy, as forests have prominent contributions to low-emissions economy, food security, and sustainable use of renewable biological resources for industrial purposes. This all should be achieved while ensuring biodiversity and environmental protection.

NTFPs are raw materials which have great potential to be developed to new products and services by new and innovative processes. Many consumer megatrends favor NTFP – based commodities, especially in food- and well-being sectors. It can even be stated that in many product sectors the demand exceeds current supply, yet many applications are still to be explored. But NTFPs are not only about economy. NTFPs have been, and are still an important part of traditional use of natural resources. When NTFPs are used in modern applications tradition and the present time shake hands.

As NTFPs are used in numerous fields of industries it is essential that also experts representing this diversity meet and share their knowledge and experiences. This is how new innovations and applications are developed. With these words we warmly welcome the guests to the Non-Timber Forest Products and Bioeconomy – conference.

We also thank our numerous co-operators which have enabled the conference. The main financers have been the EAFRD – financed National coordination project of natural product sector (LUMOA) and Regional information project on natural products (LUTUNEN).

Siberian jay (*Perisoreus infaustus*) is a prevalent bird species in north Eurasia.
Due to its inquisitive and fearless nature, it is a good symbol of scientific curiosity.

Contents

KEYNOTE ABSTRACTS

K1

Managing Portuguese Mediterranean Forests for Non-Timber Forest Products

Margarida Tomé

Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal

A large percentage of Portuguese forests located in the Mediterranean region have been managed with a strong focus on non-timber forest products, with particular emphasis on cork and pine nuts. Cork oak stands (pure or dominated by the species) cover 736775 ha which represent 23% of the total forest area, while stone pine stands (pure or dominated by the species) cover 175742 ha, 6% of the total forest area. Most of cork oak stands have historically been managed as agroforestry systems, combining trees with annual cultures such as wheat, that have been gradually transformed into silvopastoral systems that combine the trees with pastures and grazing under the trees. Recently, the use of cork oak wood, namely the one obtained from the thinning of recent plantations, is also being considered. Several management systems can be found, from stands managed with the objective to optimize cork productions to stands for which the multifunctionality is the management objective, being the stands uneven- or even-aged stands. The stone pine stands managed for pine nuts production have low stand density and are more often uneven-aged but the wood from thinnings is also an interesting product. There are also a few stands managed with the focus on wood production. The forest management approaches usually used for these Mediterranean ecosystems will be presented as well as the tools available to support forest management decisions at stand level, the SUBER and the PINEA.pt models respectively for cork oak and stone pine, both individual tree models that are implemented in user-friend computer interfaces. Finally, some case studies will be deeply analysed: 1) description of the present situation of the stand; proposal of some alternative management approaches focusing different baskets of products; 3) use of the available tools to compare the economic viability of each forest management approach. The importance of non-timber forest products will be discussed.

K2

What Works and What Does Not: exploring approaches to reconcile different forest land use practices.

Camilla Sandström

University of Umeå, Umeå, Sweden

Numerous complementary (and to some extent competing) approaches to the governance and management of natural resources have been developed, with the aim of providing guidance for the sustainable development of natural resources. Many of them, such as the Ecosystem Approach, the Ecosystem-based Approach, Resilience Thinking, the Social-Ecological System Framework, the Ecosystem Service Approach and Reflexive Governance, also offers detailed tools to guide decision-makers and practitioners on how to integrate tradeoffs in land-use decisions to minimize conflicts between different actors.

Although the approaches has differing roots (in natural sciences, social sciences or schools of science and technology studies) they have substantial similarities. Clearly, developers of these approaches have been aware of (and inspired) by the other approaches, although they all have distinctive features or emphasize different aspects. Similarities especially applies to the need to integrate various knowledge systems, the promotion of collaborative decision-making and iterative management or learning by doing. However, a comparison also indicates several significant differences between the approaches concerning e.g. the articulation of the normative objective.

Despite that these approaches are widely acknowledged, in global as well as in national polices, they all seem to provide limited guidance on how to integrate tradeoffs in land-use decision making. Conflicts regarding land use, in particular in forested landscapes, rather increase than decreases in intensity over time. By comparing the approaches mentioned above the purpose of this presentation is to explore why something that looks so good in theory, does not seem work very well in practice and to discuss what potential alternative approaches there are to guide decision-makers in the difficult task to reconcile different forest land use practices.

The presentation builds upon the findings in Mårald, E., Sandström, C., & Nordin, A. 2017. Forest Governance and Management in a Transtemporal Perspective. Towards a new forest social contract? London. Routledge.

K3

Lowbush blueberry cultivation in North America: Results of 70 years of research and development

Frank Drummond
University of Maine, Maine, USA

Lowbush blueberry is a wild plant complex that colonized the glacial outwash plains of northeast North America after the glaciers receded. The "lowbush blueberry crop" is a complex of five heath or ericaceous plant species, but is primarily comprised of "the sweet lowbush blueberry", *Vaccinium angustifolium*. It is adapted to low nutrient, course granitic acidic soils. It primarily grows as a forest understory species, but do to its shade intolerance no flower buds or subsequent fruit result. Upon forest removal either by natural causes such as wind or fire; or by anthropogenic means such as logging, sunlight induces flower bud development, floral bloom, and fruit.

The early Europeans arriving in northeastern North America in the 1600s recorded that lowbush blueberry was managed as a food crop by indigenous peoples through a "slash and burn" agriculture. This form of agriculture was adopted by the European colonists. In Maine by 1860, about 100,000 ha of lowbush blueberry was managed. Harvested fruit was transported by train and ship to the major U.S. urban areas, Boston, New York, and Philadelphia.

Little changed in production until 1905 when the invention of the harvest rake was adopted. This allowed one worker to harvest in a day as much as 20 workers hand picking. Another change that occurred in the early 1900s was the shift to manage crops more intensively on private land compared to the older state of harvesting open public lands. Perhaps the most significant change for the lowbush blueberry production system was the development of a canning industry in 1901. Blueberries canned in syrup resulted in a long shelf life that opened up more markets, especially those in the western U.S. and Canada.

Modifications to production of lowbush blueberry occurred rapidly starting in the 1940s. More frequent pruning by fire was found to increase flower bud production and enhanced harvest as lateral branch growth was reduced with a biannual (once every two years) fruit production cycle. In addition at this time, a shift occurred from using salt marsh hay spread on fields for fuel to using oil. This resulted in a hotter more complete prune (burning the above ground growth).

Since the 1950s pesticides, fertilizers, soil amendments, imported pollinators (commercial honeybees and bumblebees) were adopted by growers. The 1980s until present, resulted in development of overseas markets, and the adoption of integrated pest management and ecological and economic knowledge based sustainable production systems.

K4

Health effects and special features of Nordic berries and birch sap; Science to support product research and development

Heikki Kallio

Food Chemistry and Food Development, University of Turku, Turku, Finland

Lingonberries and bilberries are the two most effectively exploited crops among more than twenty edible, wild Finnish berries. Cloudberries, crowberries, sea buckthorn, rowanberries and arctic bramble have a special and an increasing role in both product development and research. Health claims widely distributed in various public media are only seldom proven, even though often used to support product marketing. Research has been increasingly focused on questions which help us to understand the nutritional effects and technological properties of wild berries.

A number of beneficial health effects of berries have been reported. Regular use of a selection of Nordic berries in various forms lowered significantly the liver ALAT value which may indicate reduction of the risk of metabolic syndrome and of type 2 diabetes (*Eur. J. Clin. Nutr*. **2010**, *64*, 614-621). Sea buckthorn and bilberries may have beneficial effects on CHD risk through positive changes in various cholesterol fractions and serum lipids. Women with higher cardiovascular risk factors benefited most (*Am. J. Clin. Nutr.* **2013**, *98*, 941-951). Sea buckthorn berry oil lowered aggregation velocity and total aggregation of platelets in healthy men (*J. Nutr. Biochem*. **2000**, *11*, 491-495). A low dose of SB puree further decreased the sensitive CRP concentration significantly compared to the placebo which also may indicate reduction of cardiovascular diseases (*Eur. J. Clin. Nutr.* **2008**, *62*, 1123-1130). Black currant oil taken orally by pregnant mothers and later by infants lowered symptoms of atopic dermatitis in newborns (*Clin. Exp. Allergy* **2010**, *40*, 1247-1255). The effect was based on enhancement of innate and adaptive immunity via breast milk cytokines (*Ped. All. Immunol.* **2013**, *24*, 562-566). Supercritical CO_2 technology has been applied to fractionate berries in more targeted bioactive fractions for food supplements, cosmetics and even medical devices.

Birch sap is a less exploited renewable forest resource which, according to folk lore and "common knowledge" has beneficial effects on various inflammation and diabetic problems but this has not been proven experimentally. Birch sap is commonly used as a drink and as ingredient for various drinks and fermented products. Also birch syrup process based on reverse osmosis and vacuum evaporation has opened new business areas *(J. Food Sci.* **1985**, *50*, 1330-1332.

K5

Food in modern everyday life: meanings, practices and concerns

Lotte Holm

University of Copenhagen, Dept. of Food and Resource Economics, Copenhagen, Denmark

Food is essential for human survival and for social life. In our daily lives meals are important media for building groups and social relations and the daily rhythm of meals is part of the socially coordinated routines and activities of everyday life. Further, food and meals have meanings which relate to situations in which they are consumed, to the identities of people consuming them, to cultural traditions and to issues of concern in societies.

Today, food and eating is an important element in moral discourse about how to live a proper life: healthy diets have for long been high on public agendas, more recently, environmental sustainability and climate change have become prominent dimensions of meanings associated to food and eating too.

In modern life food trends and fashions change relatively fast, but the question is, whether this is also the case for the rhythm and social context of our eating. In earlier times, regular and stable meal patterns have been typical for pre-industrial and industrial societies. But how about the post-industrial societies of today?

A huge array of ideas have been brought forward in popular and scientific debate: that meal patterns are disrupted in modern societies, that family meals are in decline, that eating has become an individual and solitary matter, and that culinary rules are dissolving. Several labels have been assigned to this alleged post-industrial, modern way of eating: *grazing, frukostisering, vagabond feeding,* and *gastro-anomie.*

Obviously, while such labels are inspiring, they may be misleading and confuse the spectacular with the general and the ordinary. After all, whether or not daily food practices have become disrupted is an empirical question.

This presentation will address questions of modern eating on the basis of a project which includes two population studies, conducted in Denmark, Finland, Norway and Sweden in 1997 and 2012, respectively. Identical questions were posed in the two years, and therefore the project allows us to discuss changes in the way we eat in modern Nordic societies. So, the theme is: *What happens to eating patterns in post-industrial societies?*

K6

Product development in small companies - a straight road to success?

Emil Byström

SpinChem AB, Umeå, Sweden

SpinChem AB is a privately owned limited company that offers simple, stable and resource-efficient technical solutions, aimed at reshaping the way chemical processes and liquid purifications are performed. The core of SpinChem technology is the ‘rotating bed reactor' (RBR). This is a modern alternative to stirred tank reactors and columns, used for applications involving heterogeneous reactions. The ingenious design of the SpinChem RBR makes for seamless scalability, and ensures both time and resource efficient workflow. By constant product development and close co-operations with multiple academic institutions, SpinChem offers solutions for many application such as processing of nuclear waste, water purification and production and development of pharmaceuticals and food ingredients. This presentation will tell you the story about the company and the evolution of the product. A straight road to success?!

ORAL ABSTRACTS

O1

Glucans from basidiomyceta: How different techniques change our extracts?

Gabriele Beltrame, Jani Trygg, Baoru Yang

University of Turku, Turku, Varsinais-Suomi, Finland

Mushrooms have been part of human culture since the beginning of civilization, used as food resource and for their health beneficial properties. Due to the Nordic and quite often rainy climate with a long Autumn, Finnish environment is very suitable for mushrooms. However, Finnish cuisine has not fully affiliated the richness of its own forests, and only 1% of Finnish forest mushrooms are collected for food.

Glucans are the main polysaccharides of the fungal cell wall. They possess biological properties, such as immunomodulatory and hypoglycemic, and therefore are of interest for the nutraceutical market. Chemical structure and molecular weight of these polymers are determinant factors for these activities. In IN Mushroom -project we tested different extraction technologies on cultivated and wild mushrooms, Agaricus bisporus and Craterellus tubaeformis, respectively.

We used four different extraction techniques to isolate the glucans from the cell walls. Next to traditional hot water extraction, fungal cell wall was first mildly disrupted by ethanol-acid hydrolysis. Also, low and high alkaline solvents were used to swell the cell wall and better dissolve poorly soluble high molecular weight glucans.

Different techniques have a notable impact on the yield, molecular weight distributions, sugar and anomeric compositions, and bioactivities.

Understanding the connection between structure and composition of glucans to the bioactivities are crucial when we design the applications for these extracts. This takes us next step closer to the utilisation of the side streams of mushroom farms and high value products of the wild mushrooms.

Keywords: agaricus; craterellus; mushroom; glucan; polysaccharide; extraction technologies

O2

Mushrooms, florals, essential oils, firewood and more! The United States' Pacific Northwest region is booming with NTFP production! Find out how a local woodland cooperative is helping landowners break through NTFP market barriers

Tiffany Fegel

Corvallis, Oregon, USA

This presentation will explore the many non-timber forest products that are gaining popularity in the Pacific Northwest region of the United States. We will cover the hunting and gathering processes of the following popular mushrooms; chanterelles, morels, and truffles including the utilization of dogs. Another mushroom we will look at is the shiitake mushroom and how people are actively inoculating these mushroom spores into logs for at home production. Floral greenery production in the Pacific Northwest is extremely productive. Our abundance of evergreens makes this a large non-timber forest product for our woodland owners. Many landowners, specifically in Oregon, have begun selling bundled firewood to high end markets. This has been a great way for our landowners to make money from wood that they cannot sell in other markets. Essential oils are a huge NTFP growing in popularity across the nation and being produced at a large level in the Pacific Northwest. We will look at how our small forest landowners are harvesting tender bough tips of native conifers for essential oil production. Oregon has a woodland owner coop that assists many landowners interested in producing these NTFPs and more, this presentation will touch on the socioeconomics of NTFPs, how small woodland owners face barriers to entering these markets, and how a woodland cooperatvie can help landowners overcome many of those barriers.

O3

WAX project - Natural wax of arctic berries as our treasure

Hely Häggman[1], Katja Karppinen[1], Nga Nguyen[1], Priyanka Trivedi[1], Eivind Uleberg[2], Inger Martinussen[2], Laura Jaakola[2], Päivi Vesala[3], Robert Joffe[4], Liva Purpure[4], Juha Väänänen[1], Janne Remes[1]

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The industrial demand for wax is about 1.000.000 tons annually from which about only 3% is covered by natural waxes and 97% (mainly as paraffin) is produced from non-renewable (mainly fossil) sources. The total market value for this market is about 600-700 M€ per year. Compared to synthetic waxes which are fossil (oil) based and chemically processed materials, the natural waxes are produced by biogenesis, renewable and thus contribute to sustainable processes and reduced carbon emission. Also, natural waxes show well-balanced composition and perform in many applications much better than their synthetic counterparts.

In Scandinavia we have very interesting candidates for domestic wax production i.e. wild berries such as lingonberry (*Vaccinium vitis-idae L.)* and bilberry (*Vaccinium myrtillus* L.) are abundantly found and important industrially utilized wild berries in arctic nature but we have also other interesting species like black crowberry (*Empetrum nigrum*) and bog bilberry (*Vaccinium uliginosum*). Wild berries are used increasingly by food industry due to their reported health and probiotic effects but much of the resource material is wasted as side stream after the food processing. In this project we want to develop methods for exploiting the raw material still present in the side stream and thus increasing its value.

The broad expertise areas of the researchers involved covering biology, technology and marketing offer excellent background for the present project.

The results achieved will be presented in the meeting.

The project is funded by Interreg Nord.

O4

Interaction of light and temperature conditions in accumulation of anthocyanins in bilberry (*Vaccinium myrtillus* L.)

Laura Jaakola[1,2], Laura Zoratti[3], Eivind Uleberg[2], Katja Karppinen[3], Anne Linn Hykkerud[2], Hely Häggman[3], Inger Martinussen[2]

[1]UiT The Arctic University of Norway, Tromsø, Norway, [2]Norwegian Institute of Bioeconomy Research, Tromsø, Norway, [3]University of Oulu, Oulu, Finland

Bilberries (*Vaccinium myrtillus* L.) are among the most important wild berry crops in the Nordic countries. We have studied the role of different light and temperature conditions on biosynthesis of anthocyanins in bilberry clones from different latitudes and altitudes, both in controlled and in field conditions. Anthocyanins are the main reddish and blueish pigments in plants, also recognized as potential health beneficial compounds in human diet. Besides contributing the characteristic colors in flowers and fruits, anthocyanins may accumulate in plant organs as response to excess of light, low temperature, and other stress factors. Bilberry fruits are one of the richest sources of anthocyanins, containing 15 major anthocyanins in addition to several recently detected minor compounds. Earlier studies have shown higher anthocyanin levels in bilberry clones of more northern origin. The present results indicate complicated interactions in the levels and the qualitative composition of anthocyanins in berries as response to light and temperature conditions. The effect of temperature was shown to be more prominent on anthocyanin accumulation than expected. Lower temperature and specific light wavelengths induced especially the accumulation of more bluish delphinidin glycosides, which have also shown higher specific bioactive properties. Deeper understanding on the mechanisms underlying the regulation of anthocyanin biosynthesis in berries is fundamental for future breeding programs, for berry production in changing climate conditions, and for novel innovations.

O5

How to boost the use of high-value substances of trees?

Tuula Jyske[1], Jan-Erik Raitanen[1,2], Eila Järvenpää[3], Risto Korpinen[1], Susan Kunnas[4], Tytti Sarjala[5], Patrik Eklund[2]

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Forest trees in the Far North latitudes accumulate high amounts of compounds with biological activities. These compounds can be extracted from forestry side-streams, or fresh biomass, such as needles, shoots, roots, bark, and tree saps. The challenge with several extractive compounds is their instability, limiting their usability in various products. In this Academy of Finland Key Project ("Boosting the use of high-value substances from trees: innovating treatment techniques for improved usability in products" - InnoTrea) we study how varying storage and processing of the biomass affect the yield and properties of its chemical compounds. We also determine whether certain treatment techniques can be applied to improve the stability of the compounds in order to add value or enhance their functionality in end products. The studied techniques will for example be focused on microencapsulation and mixing bioactive compounds with other materials. A range of forestry residue-derived extracts, such as stilbenes of Norway spruce (*Picea abies*) bark, will be selected for in-depth studies based on results from our previous studies. Research will be conducted in close collaboration with small and middle-sized enterprises (SMEs) in northern Finland. Knowledge base will be created on the possible treatment techniques and bioactive properties of the compounds or their functional combinations (e.g., antioxidant, antimicrobial, or antifungal properties) for different end-uses. The preliminary results of the project will be discussed in the presentation.

Keywords: bark, biological activities, biomass, conifers, extractives, functionality, processing, storage

O6

Pinosylvin and resveratrol in a cell model of age-related macular degeneration

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Age-related macular degeneration is the leading cause of blindness among elderly in Western countries and the number of patients is expected to increase during the next decades. AMD has significant impact on the lives of patients as well as to the public health services. Currently, there are no effective treatments for dry AMD (80-90% of all patients); the wet form (10-20% of all patients) can be treated with anti-vascular endothelial growth factor injections, which can only delay the progression of the disease.

Oxidative stress and decline in autophagy in retinal pigment epithelial (RPE) cells are linked to the pathogenesis of AMD. RPE cells are responsible for the maintenance of the retina, especially photoreceptor cells responsible for visual perception, and are therefore vital for the well-being and functioning of retina. Due to their function as a "janitors" of retina, the RPE cells are continuously exposed to heavy oxidative stress. At the same time, they have to clean and recycle old and damaged proteins in order to maintain protein homeostasis and the functionality of retina. One of the cleaning mechanisms for proteins is autophagy, a process specialized to degrade aggregated proteins and cell organelles. Heavy oxidative stress and loss of autophagic cleaning mechanism eventually lead to RPE cell death and loss of photoreceptor cells.

Natural compounds have been studied for prevention of oxidative stress for several decades. In our recent studies, pinosylvin was discovered as a powerful inducer of antioxidant defense system in human RPE cells. This stilbene compound increased the expression of antioxidant enzyme (heme oxygenase 1, HO-1) via activation of nuclear factor-erythroid 2-related factor-2 (Nrf2). Another stilbene compound, resveratrol, changed the expression pattern of autophagy markers p62/sequestosome 1 and microtubule-associated protein 1A/1B-light chain 3 (LC3) suggesting activation on autophagy. Resveratrol treatment protected RPE cells from chemically induced protein aggregation by increasing the removal of protein aggregates and cell viability.

Pinosylvin and resveratrol, found for example from pine wood park and berries, respectively, are promising compounds to combat against oxidative stress and inducing autophagy. Therefore, these stilbene compounds have the potential to prevent AMD or even being used as therapeutic drugs.

O7

Alternative approaches to integrate bilberry yields into regional long-term forest scenario analyses

Mikko Kurttila, Harri Kilpeläinen, Olli Salminen, Kari Härkönen, Jari Miina

Natural Resources Institute FInland, Joensuu/Helsinki, Finland

In Finland, picking wild berries constitutes, for households, an important non-wood forest commodity, offering food and recreational services, as well as revenues from berries sold to berry processors. Development of berry crops is therefore important from economic and socio-cultural perspectives. During the last few decades, intensified forest management has introduced practices that are affecting negatively bilberry coverage and yields. The recent development of empirical bilberry yield models enables their integration in forest management planning systems, and optimisation of the production of timber and bilberries simultaneously. In this study, regional 50-year-long forest scenario analyses were conducted to investigate the effects of four approaches to the inclusion and valuation of bilberry yields on the economics, management, and structure of the forests in North Karelia, Finland.

The current approach ignoring bilberries resulted in decreasing bilberry yields and younger forests. When bilberries were valued at the market price (1.72 € kg^{-1}) and included in the objective function (net present value NPV), forest management and the resulting forest structures were only slightly modified, and bilberry yields decreased. Adding even-flow constraints to bilberry yields resulted in a very small impact on the NPV, but forest management favoured older age classes and thus also bilberry yields. Similar effects occurred and about 90% of the NPV was still based on timber when the bilberry price was tripled to include the implicit, un-priced ecosystem benefits of bilberries in our analysis. In the approach in which the forests were managed only for bilberries with zero-priced timber, timber harvesting practically ceased and bilberry yields increased. In conclusion, managing forests for both timber and bilberry production only slightly affected the economics, but greatly affected bilberry yields in the forests in North Karelia. Ignoring bilberry production in forest management would decrease the current annual bilberry yield of 12.1 million kg by 29%, while promoting it would increase the yield by 12%.

O8

Sea buckthorn oil has beneficial effects on mucous membranes in oral and topical applications

Petra Larmo

Aromtech Ltd, Tornio, Finland

Mucous membranes cover and protect the outer surface of eyes, the urogenital, respiratory, and digestive tract. Oral and topical applications of sea buckthorn oil extracted by supercritical carbon dioxide have in clinical studies shown beneficial effects on mucosal dryness.

The prevalence of dry eye among people aged 50 years and older is even more than 30 %. Typical symptoms include grittiness, burning and redness of eyes. In dry eye, the osmolarity of the tear film protecting the ocular surface is high and inflammation occurs. Symptoms are usually treated with moisturizing eye drops that do not, however, eliminate the underlying inflammation.

Effects of a standardized combination of sea buckthorn seed and pulp oil on dry eye were investigated in a randomized, double-blind, placebo-controlled clinical study of one hundred women and men. The participants daily took 2 g of sea buckthorn or placebo oil for three months. Intake of sea buckthorn oil, compared to placebo, attenuated the rise of tear film osmolarity, and relieved the symptoms of burning and redness of eyes. As a topical application, an eyelid spray containing sea buckthorn oil and hyaluronic acid was observed in an open, randomized controlled study to relieve the symptoms of dry eye.

Associated with the decrease of estrogen, up to more than 40% of postmenopausal women experience symptoms of vaginal atrophy, including genital dryness and irritation. Also, the pH and integrity of the vaginal mucosa are impaired. Effects of the intake of combined sea buckthorn seed and pulp oil on vaginal atrophy were investigated in a randomized, double-blind, placebo-controlled study of 116 women. The intervention lasted for three months with the daily dose of 3 g of oil as capsules. In the sea buckthorn oil group compared to placebo, the integrity of the vaginal epithelium significantly improved.

The effects of sea buckthorn oil most likely were mediated by several bioactive compounds. Sea buckthorn berry oil is rich in β-carotene, a precursor for vitamin A, essential for normal skin and mucosa-associated epithelia. Sea buckthorn seed oil contains the essential α-linolenic and linoleic acid, the intake of which is important for the structure and hydration of skin. Components of both sea buckthorn berry and seed oil may attenuate inflammation associated with atrophic vaginal epithelium and dry eye.

O9

Optimization of a Designed Extraction Process of Anthocyanins from Bilberries Using Laboratory Measurements and VIS-NIR Spectroscopy

Tom Lillhonga[1], Leif Hed[2], Sami Lieskoski[1], Paul Geladi[3]

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Nordic forest berries and especially bilberries are rich in anthocyanin compounds, which have shown potential health benefits in many previous studies. The global market of these compounds is one of the fastest growing in the health related food business. The economic interest is one motivating factor to study and possibly improve the industrial process behind the manufacturing of these anthocyanines.

In this study the full scale industrial extraction process of anthocyanins from bilberries is optimized in a lab scale investigation in order to maximize the gain of anthocyanins in every batch. Performing an optimization in full scale is often not feasible and hence a lab-scale approach was necessary.

The gain of anthocyanins is influenced by process parameters (factors) as pre-treatment method used on the raw material, process temperature during extraction, ethanol to water ratio of the solvent and the initial dry mater to solvent ratio. Default process factor settings are according to best practice, but not necessarily optimized. In order to control the different process factors a D-optimal experimental design was calculated to cover the variance spanned by the factors. A total of 50 different extraction runs, including three center points, were included in the experimental design. Each extraction was repeated three subsequent times with the same initial raw material and therefore adding up to a total of 150 runs.

The extract was filtrated after each run and the eluent was analyzed with HPLC instrument for six different anthocyanines. Based on these responses a PLS-model was fitted to the data. Contour plots reveal the optimal process factor settings for maximizing the gain of anthocyanines. The results show an interesting movement of the "sweet spot" (containing the optimal factor settings) in the design space between the three subsequent extractions for the actual pretreatment used.

Additionally, all liquid phase eluent samples were measured in triplicate with VIS/Near-Infrared spectrometer. PCA models of the spectra reproduces the information obtained from the models based on the HPLC results and PLS-models were calculated to predict the anthocyanin concentration. VIS-NIR spectroscopy is more rapid, can be applied on-line and is non-destructive compared to the HPLC method. This is of great interest from a process control and monitoring point of view.

O10

Spatial Genetic Structure of resin yeilding tree Boswellia serrata, NTFP subjected to harvesting in the Western Ghats, India

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Indian Frankincense, an oleo-gum resin is most valuable non-timber forest product (NTFP) produced by *Boswellia serrata* of the Burseraceae family in India. This species occurs in the deciduous forests of Western Ghats, Eastern Ghats, Rajasthan, Gujarat, Uttar Pradesh and in other dry and tropical regions of India and is an important source of frankincense, a highly valued aromatic resin obtained from the bark of the tree. In Western Ghats, *B. serrata* populations have tremendously fragmented to smaller and isolated remnant patches, and many populations completely lack recruitment of saplings. This regeneration bottleneck, in combination with fragmentation and adult mortality, threatens the persistence of the species. Despite the economic importance of this species, virtually nothing is known about the genetic resources of this species. Information on the distribution of genetic diversity across populations, pattern of genetic differentiation, fine-scale genetic structure and how it varies acrosss generations are crucial for designing appropriate conservation strategies.

In the present study we assessed the genetic diversity and fine-scale spatial genetic structure (FSGS) of two cohorts (adults and seedlings) from two populations of Biligiri Ranganathaswamy Temple (BRT) Tiger reserve in the Western Ghats and inferred intra-population gene dispersal in the species, using 10 microsatellite markers. The mean level of observed and expected heterozygosity was 0.795 - 0.809 and 0.812 - 0.8225 respectively and a moderate level of among populations genetic differentiation (FST = 0.084) was detected. The spatial analyses based on kinship coefficient (Fij) revealed a significant positive genetic correlation up to a distance of 125m. Spatial genetic structure was relatively weak (Sp = 0.002-0.014) indicating that gene dispersal is extensive within the populations. We estimated indirectly gene dispersal distances of 106 and 135 m for the two populations studied based on the FSGS pattern.

High levels of genetic polymorphism and significant levels of inbreeding were found, indicating outcrossing as the major mating system in this species. High degree of inbreeding, relatedness, intra-population spatial genetic structure and seed dispersal distance, indicates limited seed dispersal. These results have significant implications for species persistence in the landscape. Increased inbreeding due to mating between few adult trees causes reduced seedling performance, which potentially constrains recruitment in this species. Restoration efforts such as transferring seeds among populations may be essential to mitigate these processes and ensure the persistence of this species, which is vital to supporting the livelihood of people who are dependent on this species in these landscapes.

O11

Commerciality meets local berry picking culture - threat to the human territoriality?

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In Finland, Everyman's Rights guarantee free public access to both private and public forests. As a part of this statute, wild berries and mushrooms can be picked without a forest owner's permit. The nature of wild berry picking has, however, changed during the recent years. While traditionally berries have been picked for the private consumption and by the locals, there has been an increasing trend for commercial wild berry picking, as in order to safeguard the raw material supply, the berry companies have started to bring foreign pickers for the season. Even though there is no regulatory obstacle for using foreign pickers, they are often regarded with suspicion. As a result, an intense public discussion in Finland has questioned whether commercial berry picking violates the spirit of Everyman's Rights, and the forest owner rights.

This study analyses the problematic of commercial berry picking from the perspective of the theories of psychological ownership and human territoriality. Psychological ownership can be defined as a state in which individuals perceive an object, entity or idea, as "their own". Thus it is an individual feeling, which can exist in also in the absence of legal ownership. As one behavioral consequence of this feeling territorial behavior has been detected. Human territoriality refers to a set of behaviors and cognitions exhibited by a person or group based on the perceived ownership of for example a physical space or an idea or innovation.

We argue that understanding these experienced ownership feelings as well as the territorial behavior resulting from them can play a significant role both in successful co-operation among the different stakeholders and in tensions related to the use of natural resources. We also suggest these theoretical concepts enable us better to understand the complexity of the berry picking conflicts.

The aim of this paper is to present the results of the phone interviews of 250 private forest owners concerning their views and attitudes on Everyman's Rights and commercial berry picking. Reflecting the results to the theories of psychological ownership and human territoriality, the results of this study demonstrate what aspects of commercial berry picking are disturbing private forest owners and how the relation between commercial berry picking firms and forest owners could be improved.

O12

Diversified use of forest ecosystem services

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Finnish Forest Strategy 2025 and Finnish Bioeconomy strategy have large-scale impacts on the forest use, criteria of forest certification, forest planning, and forest owners' decision making. New methods and tools are needed to evaluate the impact of the strategies on the production of ecosystem services, to develop methods that promote the multiple use of forests, and to disseminate the new information to forest actors. Natural products are promising ecosystem services that may reach the importance of wood as providers of benefits from forests. Consideration of natural products in forest planning requires special expertise and knowledge of production possibilities.

Our project ‘New products from forests' aims at promoting the sustainable and diversified use of forests and its objectives are: 1) To increase the multiple use of forest ecosystem services by taking into account the needs of the society, private forest owners and entrepreneurs in natural products, 2) To provide information on the production of wood and other ecosystem services, in particular natural products, 3) To develop Forest Indicator, a web based tool which shows the changes in ecosystem services as a result of forest use, 4) To develop, pilot and instruct forest planning that considers the production natural products in private forests, and 5) To develop models that calculate the profitability and trade-offs of the production of natural products.

The project supports forest owners' decision making and the implementation of regional forest programs. In the long term, the project supports sustainable bio-economy and regional development. The present phase of the project and first visualization plans of the Forest Indicator will be presented.

O13

Limits to NTFP commodification: implications for their coordinated management and governance

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Non-timber forests products (NTFP) are ecosystem goods and services, either provisioning or cultural. Many of them are privately owned. Exploitation of them only can happen with a permission of the land owner. In Finland forest berries and mushrooms are open access resources; we have everyman's rights to collect them. Recently markets have expanded significantly into new environmental domains and probably also to open and common resources. A general goal in market economies has been to find new arenas for markets to operate and simultaneously the enlargement of capital circulation and accumulation. The commodification discourse dominates and the idea of market creation through the privatization of still open and common parts of nature is popular.

Despite the fact that the market enlargement is currently fast, it is still restricted by two forces - a) an impossibility of the physical commodity form, and b) some ethical and cultural aspects. Erik Gómez-Baggethun and Roldan Muradian (2015) have studied the reach and legitimacy of the markets. They found four types of boundaries to commodification: 1) Biophysical limits relate to the difficulties that arise in the attempts to break down ecological complexity into compartmentalized tradeable units. Ecosystem services are intertwined with one another and emerge from complex relations between interacting ecosystem processes and components; 2) Related type of technical boundaries relates to the institutional character of ecosystem services in terms of rivalry and excludability. Market exchange presupposes excludability in supply and rivalry in demand. As we move along the continuum from ecosystem services with private to public good character, the transaction costs to enforce exclusion mechanisms increase to levels that in general do no longer make markets viable; 3) Ethical boundaries derive from the normative presumption that some things should not be for sale, and 4) Right-based or political boundaries stem from active opposition to the expansion of specific policy instruments involving re-definition of property rights into new environmental domains.

Provisioning ecosystem goods and services, such as NTFPs, are connected to the renewability and resilience of ecosystems. Their sustainable management presumes governance of the whole social-ecological system (SES). An integrated approach that bundles services may be more effective than separate programs for each ecosystem services when providing them sustainably at an ecologically relevant scale. As a result, also NTFP commonification and recommonification are viable instruments in the politicians' toolboxes.

O14

Securing NTFP yields in a nature – based tourism resort

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Majority of the world's population is estimated to live in urban environment by 2050. This, with the commercialization of outdoor recreation, feed nature-based tourism. In Finland, 30% of foreign tourists and 40 % of domestic visitors participate in nature activities provided mostly on winter seasons. Nature activities for summer season are, however, sought to promote year-round tourism.

Popularity of NTFP picking, once widely practiced in Europe, is decreasing due to urbanization. Nature activities involving NTFP collecting might offer an appealing activity. Customers from central Europe represent ca. 50% of the foreign tourists visiting Levi, the largest tourism resort in northern Finland. NTFP collecting could familiarize tourists to local wild food and emphasize the origin of food along with revitalization of picking tradition.

However, such an activity requires easy access to collecting areas. Additionally, a certain NTFP yield should be ensured. Levi tourism resort has comprehensive network of walking routes in the lower slopes of the Levi fell, in which the cover of bilberry (*Vaccinium myrtillus*) vegetation is good. This means that accessibility and potential availability of NTFPs are combined.

In this study, two methods to secure bilberry yields were tested in three sites of the Levi fell, two ski slopes and one forest clearing. The study was implemented by establishing meadows of nectar-bearing plants and by setting artificial pollinator nests (birch blocks with 4, 6 and 8 mm diameter holes, drilled to 110 mm depth). The nests were placed in close proximity of the meadows. Share of pollinated bilberry flowers near the nests were determined on the following year by calculating flowers and raw berries from observation squares (five $1m^2$ squares / area).

On the first year, share of pollinated flowers near the artificial nests placed to forest clearing was clearly higher as compared to an area with similar forest type without artificial nests (53±13% and 28±12%, respectively). It seems that there were differences in the availability of flowering plants between the sites. The blooming of the natural meadow plants in the forest clearing was abundant, whereas it was chiefly the annual species that bloomed in the established meadows of the slopes. It may partly explain why the combination of artificial nests and meadows did not improve berry yield in ski slope areas. Due to this as well as the high annual variation of pollinator populations, monitoring of the yields will continue the following years.

Keywords: Bilberry, Vaccinium myrtillus, tourism

O15

Innovative use of berry seeds in cosmetics

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Natural, safe and healthy are the megatrends in global cosmetic and food industry. Many cosmetic ingredients are synthetic, especially the preservatives, which are associated with many negative or even toxic effects by the consumer. Also legislation is starting to react, and in the near future there will be restrictions related to them. Thus, cosmetic industry is looking for alternative approaches to replace synthetic ingredients by safe alternatives. This means very high increase in the markets of natural antimicrobials in the near future. Plant based natural compounds and extracts have raised a lot of positive interest and they are screened at the moment by many cosmetic companies for their preservative characteristics and other positive activities.

Sustainability and eco-friendliness are the "must" terms of modern cosmetics. Thus, utilization of plant-based ingredients, especially industrial side stream-based, as raw-material for natural ingredients has raised a lot of interest.

The role of skin microbiome in skin health is one of the hot topics in cosmetic research. Skin is the largest organ of human body, harboring one billion microbes/cm2, and cosmetic companies are just now starting to understand the importance of a healthy skin microbial community to the general health and wellbeing of the skin. New product category is just entering the market focusing on supporting and stabilizing healthy skin microbiota by limiting the growth of harmful and pathogenic microbes and supporting the growth of beneficial ones.

Finnish berry knowhow is very strong and has been active since 1980´s. VTT has focused on berry research for 20 years, especially on antimicrobially active phenolic compounds. One of the main topics has been the berry side streams and their utilization aiming on utilization of the berry raw material totally, and minimizing all the side streams.

We have developed berry and fruit based natural antimicrobial ingredients for the cosmetics originating from the berry and fruit side streams by novel technologies. Three technologies have been patented and they are based on 1) dry fractionation technologies using seed sanding and 2) mild and gently milling and 3) extraction technologies, and thus are also suitable for food purposes.

In addition to antimicrobial activity the fractions provide several important technological advantages as cosmetic or food ingredients: totally water soluble, free of toxic solvents or reagents, good storage life.

O16

Biological activities and chemical composition of slow pyrolysis liquids obtained from pine stem wood biomass

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The wood originated liquids obtained after slow pyrolysis of pine stem wood was tested in this study. The distillates were produced by slow pyrolysis process using the research apparatus previously developed by UEF. The wood processing and analyses of the samples were done 2014 within NORPYRO project funded by Tekes.

Three main fractions, with two phases in each, were obtained from three process stages: drying, torrefaction and pyrolysis.The distillates were tested for their antimicrobial activity with agar diffusion tests. After adding pathogenic test microbe (*Listeria monocytogenes* (Gram positive bacterium), *Salmonella infantis* (Gram negative bacterium) or *Candida albicans* (yeast)) as top agar suspension the liquid sample was added in well on agar plate. After incubation period the antimicrobial activity was evaluated by determining the inhibition zone around the wells. Cytotoxic activities of distillates were tested with using HePa-1 cell line. In addition to the antimicrobial activities a simple chemical characterization to most important chemical groups by using NMR and semiquantitative 1D-GC-MS was performed.

The results indicated that the biological activities of distillates tend to increase with the processing temperature. The biological activity was typically stronger in the fractions of oily character, when the oily and the water containing fractions from the same processing temperature were compared. The increment in the processing temperature increased strongly both the antimicrobial and the cytotoxic activities. Also the chemical compositions were different between different activities. Methanol extraction and followed GC-MS-analysis proved to be fast, simple and reliable method for the chemical characterization of pyrolysis liquids. Concentrations of organic compounds (eg. phenols, esthers, aldehydes, ketones and furfural) were clearly higher in the oil phase compared to the water phase as indicated by GC-MS and NMR analyses. On the other hand, certain water-soluble and volatile organic compounds (e.g. acetic acid and terpenes) were more present in the water- phase compared to oil-phase.

O17

Non-timber forest product species management in arid tropical forest, Southern India

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Historically, non-timber forest products (NTFPs) are the vital sources of livelihoods for forest dependent communities. More than 63 percent of the studies in recent years have reported that extraction of NTFPs was sustainable. NTFPs harvest symbolizes the sustainable development concept especially in forest landscapes and seeks a win-win solution to problems of conservation and development. A study was carried out in South India to understand the impact of harvest, dynamics of change in people's relationships with the resource. We used long term ecological monitoring data on population structure, regeneration, fruit productivity and extraction of Phyllanthus emblica, P.indofischeri and Terminalia chebula for the years 2000-01, 2007-08 and 2014-15. Participatory research methods were employed to understand the impacts of socioeconomic transition, accessibility change and volatile market on NTFPs. Results indicated that population structure in the first and second years were unstable. Stable (reverse ‘j' shaped curve) population structure were observed in third year. Other than the fruit harvesting, the combination of exogenous factors like hemi parasite infections, invasion of lantana, consecutive drought and grazing significantly caused population decline. The combination of these factors significantly affected population structure, regeneration and productivity. The study also revealed that change in dependency; accessibility regime and market dynamics have played an important role in reshaping the population structure. This multidisciplinary approach is critical for NTFPs species which are at-risk due to multiple disturbances in indentifying important drivers of population decline. The study results helped in identifying important drivers of population decline and developing management strategies.

Keywords: NTFPs, Population structure, Market dynamics, Accessibility regime and Tropical forest

O18

Taste characteristics of wild edible Nordic mushrooms

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Nordic wild edible mushrooms have an annual harvest of billions of kilograms, but only a fraction of this harvest is utilized as food. Numerous bioactive compounds make mushrooms valuable food ingredients for forest based bioeconomy. The scientific examination of taste differences using analytical sensory research methods is still scarce. This study was conducted to explore the taste properties that differentiate Nordic edible wild mushrooms from each other and from cultivated mushrooms. We applied Projective Mapping combined with Ultra Flash Profiling in our sensory laboratory (ISO 8589, University of Turku). Both wild (n=4) and cultivated mushrooms (n=5) were used as samples. The untrained volunteer subjects (n=53) were asked to classify mushroom samples according to their taste sensation. The responses were digitized, and principal component regression (PCR) was used to study sample grouping and differences in descriptions. Multivariate analyses with full cross validation were carried out with Unscrambler X (version 10.4, Camo Software, Oslo, Norway). The mushroom samples were separated into three groups in PCR model: wild mushrooms, processed cultivated mushrooms and fresh cultivated mushrooms based on their taste properties. The study results demonstrated that 1) human subjects differentiate the taste of wild mushrooms from cultivated species, and 2) the perceived taste properties of fresh and processed mushrooms are different.

O19

Optimizing the joint production of timber and marketed mushrooms in North Karelian spruce stands.

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The use of mushrooms among other non-wood forest product is predicted to increase in Finland and worldwide. The yields of marketed mushrooms in Finnish forests are notable but mainly forest management aims at timber production. Knowing the optimal stand management for joint production of mushrooms and timber would provide valuable information for forest owners and further the multiple use forestry.

In this study the *Boletus edulis* and *Lactarius* spp. yield models were included in the stand growth simulator and the joint production of mushrooms and timber was optimized by maximizing soil expectation value in even-aged *Picea abies* stands in Eastern Finland. The stand management was optimized for timber and *B. edulis*, timber and *Lactarius* spp. and timber and all mushrooms (*B. edulis* and *Lactarius* spp.) The assumption was made that the stands produced good mushroom yields and 95 % of *B. edulis* and 75 % of *Lactarius* spp. yields were harvested. Harvesting costs and mushroom prices were included in calculations.

The optimal stand management schedules for joint production were very similar to that of timber, possibly due to the fact that the best mushroom yields were obtained already before the first commercial thinning. The mushrooms and timber can be co-produced, because they are not strongly competing with each other. However, if mushroom production was the only aim of stand management, the optimal rotation length for *B. edulis* production was shorter and thinnings lighter. In case of *Lactarius* spp. a management schedule with no thinnings was the most suitable. The profitability of stand management considerably increased when the additional incomes from mushroom production were included in.

Keywords: Boletus edulis, Lactarius trivialis, Lactarius torminosus, Lactarius rufus, forest management, multiple use forestry.

O20

Natural products in forest planning: a pilot study in privately owned forests in Northern Finland

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Today many forest landowners have various goals with respect to the management of their forests. For example, the forest owner may be interested in such a form of management which produces, besides income from timber sales, also additional income from natural products (e.g. resin, pakuri). The truth is, however, that the practical forest planning in Finland, and elsewhere, is dominantly single-objective aiming at allocating forest management measures for timber production only. In this presentation, we will demonstrate how natural products can be integrated in planning process and discuss challenges that forest planning system designers will face when developing genuine multi-objective planning.

For the study, six private forest estates were selected in northern Finland. For these pilot forests, forest plans considering the production of natural products were compiled using the multi-objective and interactive planning process. The five phases of the process were: (1) Interview of the forest owner to inquire the goals for the forest management. (2) Field inventory of 21 different natural products. (3) Construction of two different forest plans using Monsu forest planning program. Plan A considered those natural products that the owner was interested in and plan B was traditional timber production oriented option that served as a comparison. (4) Decision-making session where the owner considered management options and detailed his/her management objectives. (5) The final plan was compiled according to the wishes of the owner and delivered to the owner.

The process was conducted by the research team interactively with forest owners and in close cooperation with forest professionals. An approach of design-based research was applied. Three evaluation meetings were organized along the design process and after each meeting materials and instructions used in the practical planning were refined. Design cycles were consistently documented along the process that resulted in diverse research materials, including audio recordings in authentic planning sessions and in evaluation meetings, and feedback surveys and interviews with planners and forest owners. This data serve us basis for this this presentation.

O21

Cloudberry (*Rubus chamaemorus L.*) pre-breeding trials

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Two different selected female cloudberry clones (‘102' and ‘306') and two previously released cultivars (‘Fjellgull' and ‘Fjordgull') have been evaluated for production potential and quality in a field trial at NIBIO Holt in Tromsø. The field was established in 2010 and consisted of two separated benches where each bench included plots for the four female genotypes as well as two additional plots including a mixture of three different male genotypes (‘Apollen', ‘Apolto' and ‘H510'). Registrations on the traits including flowering, yield, berry size and content of secondary metabolites (anthocyanins, polyphenols and ellagic acid) have been performed from 2012 to 2016. Recorded weather data of the experimental site have given a good basis to distinguish between genetic and environmental influences on the different evaluated traits as well as the interactions between genotype and environment.

Results reveal large variation in all evaluated traits. Clone ‘102' had the largest berry size and was the highest yielding clone. ‘Fjellgull' produced most flowers and berries, but due to the small berry size it still had the lowest yield. Berry yields have shown a decreasing trend over the years, mainly due to decreasing berry sizes. ‘Fjordgull' berries contained most anthocyanins, even if the levels were very low, while berries of ‘Fjellgull' had the highest contents of polyphenols and ellagitannins. Heritability estimations show that number of flowers and berry size are good selection criteria for yield. For berry quality, total polyphenols could be a good selection criterion due to the strong correlation to content of ellagitannins, which is the dominating group of polyphenols in cloudberry. The clones ‘102' and ‘306' both show good production potential and are both suited candidates for future cultivar release.

O22

Public right of access to private land: examples and considerations

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Public right of access, everyman's right, freedom to roam, and the right of public access to the wilderness are terms used for concepts that give people an independent right of access to rural or forest areas for recreational or passage purposes. Access to private land is not a self-evident right, nor are the practices in different countries alike. The legislation and practices regarding public access depend largely on cultural, historical, and political differences and thus there are no international or unambiguous definition as to what is included in the concept. The right may concern only a right to walk or allow a variety of activities in the forest or countryside, regardless of the ownership of the land. In this paper we review how the public right of access is resolved in various countries, with a focus on the cases of Finland and Sweden. Finland and Sweden hold similar traditions of extensive access rights, more commonly called "everyman's right". These custom-based systems have been later outlined in a multitude of regulations, but have remained open to all and they are comparably inclusive. The concept has worked considerably well over time, but as the original reasons for the right have in part disappeared, and as the demand for recreational use of land has increased, the question has been raised whether everyman's right should be redefined to prevent conflicts between users and landowners and to avoid overexploitation of natural environments. We also discuss aspects that may make everyman's right prone to features related to the tragedy of the commons.

O23

Comparing the potential of Non-Wood Forest Products across case studies in Europe

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A lack of knowledge on the socio-economic relevance of NWFPs for European societies and diverse property rights frameworks increase the complexity in forest decision making for forest owners. Given the current state of knowledge regarding NWFPs in Europe, expert based approaches can help to analyse both socio-economic and ecological dimensions of natural resources, when quantitative information is limited. In this contribution we analyse the diverse range of opportunities NWFPs may provide to forest owners who are willing to tailor their forest management towards the joint production of wood and non-wood goods or focus their management on specific NWFPs production systems.

The potential of 38 NWFPs was investigated by means of multi-criteria analysis, including stakeholder interaction and expert involvement. We investigated the potential in different biogeographical zones covering the three major biomes in Europe (i.e. Subtropical, Temperate, Boreal) and discuss economic, social as well as ecological potentials in selected case study regions (i.e. Alentejo, Catalonia, Extremadura, North Karelia, Styria, Transylvania). The following tasks were conducted in each of the case study regions iteratively: i) nomination of case study responsible persons, ii) identification of NWFP sector experts and NWFP stakeholders, iii) selection of regionally relevant NWFPs, iv) forest owner profile selection, and v) stakeholder and expert consultation. For the cross case study comparison one NWFP out of four categories were selected: Mushrooms & Truffles, Understorey plants, Tree products, Animal origin.

It became evident that "Market potential" and "Resource potential" appear to be of high relevance for all case studies in the different biogeographical zones in Europe, followed by "Requirements" and "Institutional potential". Results indicate the latent opportunities NWFPs provide to forest owners who are willing to focus their management on the joint production of wood and non-wood resources. Even though regional perspectives differ, due to varying socio-economic and ecological environments, there is huge potential to strengthen the economic viability of rural areas as well as the ecological integrity of forest ecosystems across Europe.

O24

Empirical juridical approach to production of NWFP´s – Entrepreneurs perspective on the restrictive or supportive policies in Finland

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The Non-wood forest product (NWFP) production, from primary production to retail, is controlled by several different laws and statutes governing land use practices, production and food safety. The national legislation in EU is governed by EU legislation, but there are differences how Member states interpret and implement this legislation into their national law.

As novel products and production techniques are introduced, legislation governing production, refining and marketing of NWFP´s is often lagging behind the business development. This creates a situation where there are more statutes that restrict the production, refining and marketing of NWFP´s than incite the development of the sector. This creates a paradoxical situation, where the EU or national legislation encourages the enterprises in NWFP sector to outsource parts of production to countries outside EU, where there is less regulation and control. At the same time, differences in interpretation and implementation of EU legislation in member countries results in outsourcing parts of production also within EU. Hence some enterprises outsource their production to other counties within EU, where national level regulation is less restrictive. This causes bias in EU considering possibilities to engage in new business.

The aim of this study is to view how EU and national level legislation and policies affect the production of NWFPs in Finland. The problem is viewed from manufacturer/producer perspective by means of thematic interviews and data collected from workshops. Legislation covers both the collection and active production of NWFP´s in forested areas (Land use/Forest legislation) as well as what products are allowed to be produced (Food safety legislation).Results of the study are discussed in the poster.

POSTER ABSTRACTS

P1

Mushrooms: forest resources with wide application potential

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Humankind has regarded for millennia mushrooms as a food and medicinal resource, especially in Eastern cultures. In Finland, where they constitute the second edible forest biomass, mushrooms have been appreciated for both their culinary and ethnopharmacological values. Despite this, every year only around the 1% of the whole forest mushroom production is collected, leaving this abundant biomass largely unexploited.

The research that has been conducted on Basidiomycetes in the past decades shows that their application can go beyond picking and consumption, covering fields like drug research, nutraceutical market, feed and wood industry. Mushroom exploitation in such different fields could transform this forest undervalued biomass in important starting material, boosting bio- and green economy.

During the exploration of natural resources for compounds of potential pharmaceutical interest, basidiomycete secondary metabolites have been extracted, characterized and tested in their biological activities. Forest mushrooms have proven to contain molecules (sesqui- and triterpenes, polyketides, proteins etc.) with cytotoxic, cytostatic, anti-proliferative, antiviral, antibacterial, antifungal and anti-Alzheimer activities.

Mushroom enzymes, in particular from wood-rotting species, have multiple and scarcely studied potential applications in wood technology: pretreatment of wood and agricultural waste for pulp manufacture; pitch degradation for pulping; modification of fibers for wood composites; digestion of lignin for bioethanol production; treatment of waste effluents. Mushrooms and mushroom enzymes can be used for pretreating lignocellulosic feed material, whose high content in lignin and non-starch polysaccharides might hamper its utilization.

The main components of Basidiomycete dry fruiting bodies are β-glucans, proteins and chitin. The wide spectrum of biological activities of β-glucans, such as immunomodulatory, anti-nociceptive, hypocholecterolemic, hypoglycemic and prebiotic, is proven by a large body of evidence. These properties, coupled with their relative safety, make mushrooms a resource of bioactive fiber with application as nutraceutical and food ingredient. Lately, the immunomodulatory properties of β-glucans attracted interest also on mushrooms as feed additives. Chitin and chitin-glucan complexes have, on the other hand, potential as biomaterials for wound healing, packaging and drug delivery.

Keywords: mushroom; enzyme; pharmacology; glucan; chitin; feed; nutraceutical

P2

Utilization of wood processing residues for specialty mushroom cultivation

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Forest industries generate considerable amounts of low-value residues that are mainly used for energy production. A single sawmill can produce residues, e.g., woodchips up to 70 000 t of dry weight annually. To add value to the production chain of wood companies, a sustainable way of wood residue management is proposed. This study investigates the possibility of using sidestreams of wood mechanical processing as substrates for the cultivation of a high-value specialty mushroom, reishi (Ganoderma lucidum). Reishi is a well-known nutraceutical that has been used as a traditional medicine for centuries in e.g. Japan, China and Korea.

Several strains of G. lucidum from different geographical locations in Finland were chosen to evaluate the fruiting body yield and biological efficiency using Pinus sylvestris, Picea abies, Populus tremula, Betula pendula and Larix sibirica species as substrates. The substrate bags (1 kg dry weight) consisted of 60% wood chips and 40% saw dust, with wood moisture content on oven-dry basis of 65 - 75%, were autoclaved and inoculated with 150 ml of G. lucidum barley spawn. When the mycelium colonized the entire substrate bags, they were kept at 26˚C with a relative humidity of 85% to support fruit body growth. The fruit body yield was determined by counting and weighting the fruit bodies. The biological efficiency was calculated considering the kilograms of fresh fruit body per kilogram of dry substrate.

Preliminary results suggest that wood waste sidestream can be utilized as a substrate for cultivation of G. lucidum. Difference in the mycelium growth rate of the strains was observed. The results will be discussed in detail in the poster.

This study was funded by EU Rural Development Programme for Mainland Finland 2007-2013 as part of the project SieVi - Mushroom cultivation as a practice of agroforestry based bio-economy.

Keywords: Ganoderma lucidum, mushroom cultivation, wood substrate, wood processing industry, wood sidestream.

P3

Making Shiitake Happen: inoculating hardwoods with shiitake spawn for small scale production

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Shittake (*Lentinula edodes*) mushrooms are grown around the world and are the second most commonly cultivated edible mushroom. Why? Because their rich texture and smoky flavor have captured our taste buds, not to mention that they are one of the healthiest foods on the planet! This presentation will discuss how Oregon's woodland owners are growing this mushroom as a non-timber forest product in the understory of their forests. We will review the entire process from selecting a host log, inoculation, cultivation, and harvest. Also, we will hear the human dimensions side of this non-timber forest production through stories from the Pacific Northwest regions small woodland owners.

P4

Commitment readiness and interests of forest owners towards Wild Forest Product production

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The Finnish wild forest product (WFP) sector has based its production dependent on the collectible raw materials harvested by everyman's rights. This is well illustrated in the MARSI statistics, where wild berries and fungi are the most important wild forest products collected from the forest.

The annual variation in the volumes of WFP`s obtained can be considerable. One of the key problems identified by the industry is the problems related to the availability of raw materials. This has partly led to situation where the value added by refining of the products remains low.

There has been of little benefit to forest owners of WFP`s besides birch sap, spruce buds and spruce sap which are excluded from collection by everyman´s rights. Of these, the importance of birch sap has been the most prominent due to the growing market of tree waters worldwide. Besides aforementioned products, novel methods have been developed for the production of WFP`s over the past decade. From these, the direct benefit of the sale goes to forest owner. Though of the revenue that the methods offer, they require the contribution of a forest owner to produce these products, whether financial or self-employed.

Production of WFP`s and commitment of forest owners towards production would allow the utilization of the logic of industrial production comparable to wood production. Production could be planned along with forest planning, and also to estimate the yearly crop as well as additional income alongside forest production. To do this, the attitude of forest owners to production and the ability to do so are a precondition for launching production and creating functional value chains.

The purpose of this study is to examine the interest and commitment readiness of forest owners towards the production of WFP`s with a Webropol survey. The study considered only those products and raw materials that are excluded from everyman´s rights and for which primary production methods have been developed.

The questionnaire sought to find out what is the interest of forest owners and the potential level of commitment to the active production of WFP`s, thus securing the availability of raw material. Based on the results of the survey, we were able to create a picture of the possibilities to build value chains in the WFP sector, where forest owners are also committed to the production chain. In this way, the processing industry is also able to respond to big international orders better.

P5

Thicket as a raw material for valuable extractives

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Thickets of mainly birch (*Betula*), willow (Salix) and alder (*Alnus*) grow on the borders of fields, forests and roads, and are often routinely cleared for landscaping. The cleared material is either burned or left on the growing site. However, this poorly valued material could serve as an interesting entry to the valuable wood extractives that could be utilized e.g. in food ingredients, cosmetics and pharmaceuticals. These extractives consist of fatty acids, triterpenes, sterols, and phenolic compounds such as tannins, flavonoids, and stilbenes. Wood extractives are concentrated especially in the bark and leaves of trees, whereas their content in inner wood is low. In thickets, the proportional content of bark and leaves is higher than in older trees, and therefore their valuable extractive content is expected to be high.

In this study, the extractive composition and content of birch, willow and alder thickets were analysed. Samples were collected from the border forests sites in Kajaani, Finland. Leaves, bark and wood of each species were separated, dried and milled. Samples were extracted and analysed by spectrophotometry, liquid chromotagraphy (HPLC-DAD and FD) and gas chromatography (GC-MSD and GC-FID) to evaluate the potency of the thicket type as a raw material for different extractive compound groups. In addition, hydrophilic antioxidant activity of each sample was measured by ORAC (oxygen radical absorbing capacity) method. As expected the composition and content of extractives varied significantly between different thicket species and their different parts. For example, majority of hexane-acetone soluble compounds (GC-MSD and GC-FID analyses) were located in the leaves and bark of thickets: Triterpenes were the major components in the birch and alder bark extracts, as well as in the alder leave extract. In addition, birch bark extract contained significant amount of sterol esters. The hexane-acetone extracts of wood part of all species contained mainly free fatty acids: palmitic and stearic acids and in addition free beta-sitosterol.

Keywords: wood extractives, thicket, GC-MSD, GC-FID, HPLC, ORAC

P6

Monitoring chemical composition of berries during aging

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Berries are rich in nutrients and bioactive compounds. In industrial use, microbial and enzymatic processing are widely used to modify the composition. There are studies on metabolic profiles and changes in chemical composition in relation to in vitro processing. However, there are not many studies on the degradation and microbial processing of the compounds when berries are aging in nature. The natural bacterial and enzymatic composition may differ resulting in varying metabolic profile and degradation rate. In this study, we monitored changes in chemical composition of aging berries.

Finnish berries (bilberry, lingonberry, cloudberry, strawberry, and sea buckthorn) were harvested in triplicates. Part of the berries were frozen in fresh and rest of them were stored under normal atmospheric conditions for 2, 4, 7, 14, and 21 days and at each time point, a subsample was collected and frozen. The frozen samples were later homogenized, extracted and analyzed. Total reduction potential (Folin-Ciocalteu), vitamin C concentration, pH, and sugar and organic acid composition were determined.

The measured concentrations of freshly frozen samples were similar to previously published ones. During the storage period, vitamin C and sucrose were metabolized most rapidly. Glucose and fructose were more stable, although in sea buckthorn they completely disappeared in two weeks. In lingonberry, glucose and fructose were intact and nearly 30 % of sucrose was still present after three weeks. Organic acids were more stable than sugars. Malic acid content decreased first, except in cloudberry where it initially even increased. During storage, the concentrations of citric, quinic, and benzoic acid were relatively stable, except the benzoic acid content increased in lingonberry. Total reduction potential was mainly stable. However, some effect of dehydration was observed. All of the berries had pH in the range of 2.6 - 3.6. Lingonberry and sea buckthorn had a small increase and rest of the berries had a small decrease in pH during the storage period. Interestingly, one of the bilberry replicates from a different habitat showed a distinct profile for total reduction potential, sucrose, xylose, and organic acid composition as well as smaller changes in pH.

The stability of the compounds varied between the berries. The growth environment and its microbiome may also affect the degradation of the compounds. In the future, we aim to identify some of the natural bacteria present in the berries.

Keywords: berries, aging, storage, chemical composition

P7

Proanthocyanidin Profile of Commercial Lingonberry Juice

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Lingonberries (*Vaccinium vitis-idaea*) are commonly found in Nordic forests and typically have notably sour, bitter and astringent flavor. The berries have high contents of various polyphenols, such as proanthocyanidins (PAs) and flavonols. These compounds are well-known astringent and bitter compounds thus they may contribute to the flavor of the berry. Bitterness and astringency are flavor characteristics of various polyphenol-rich foods, and these features are often perceived as negative by consumers. Although in some foods and beverages they may be considered as wanted characteristics, in many cases they are among the key factors limiting the consumption of the potentially healthy plant-based food.

Aim of this study was to accomplish PA profile, especially concerning the degree of polymerization (DP), for the commercial lingonberry juice with HILIC-ESI-MS-SIR. The DP may have a great influence on the bioavailability and bioactivity of PAs, hence, the size distribution of PAs should be considered when health effects are evaluated. Both full scan and single ion recording (SIR) functions were used to analyze PAs from commercial pectinase treated lingonberry juice. The total ion ESI-MS analysis was carried out by scanning ions from *m/z* 250 to 3000 for oligomer size screening. The *m/z* signals chosen for the SIR were the most abundant deprotonated proanthocyanidin ions calculated based on the nominal masses.

16 proanthocyanidins were identified with mass spectrometry. The highest degree of the polymerization was nine. Both A and B linkages between monomeric units were detected. The most abundant PAs were di- and trimers. Results of this study are accordance with the literature although due to the different analytical methods somewhat different PA profile was detected. Processing of berries and other plant-based typically affect the concentrations of the PAs, which may explain the differences between the literature and the results of this study. Future research is needed to examine if these compounds contribute to lingonberry flavor and if the sensory quality can be modified without affecting the unique flavor and possible healthiness of the berry.

Keywords: degree of polymerization, HILIC-ESI-MS-SIR, lingonberry (Vaccimun vitis-idaea), proanthocyanidins

P8

Round-leaved sundew (Drosera rotundifolia) as a source of naphthoquinones for pharmacological purposes - Study for sundew cultivation on drained nutrient-poor peat bogs in Northern Satakunta, Finland

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Round-leaved sundew (*Drosera rotundifolia*) is a carnivorous plant growing mainly on nutrient-poor peat bogs. It uses insects as a source of nitrogen and phosphorus. Sundews contain naphthoquinones which are pharmacologically active compounds and these plants have been used traditionally as cough medicine. Round-leaved sundews are not presently endangered in Finland and they are collected from natural stands. However, possibility to cultivate sundews would improve the availability and would boost commercialization and development of new high-value products.

The dominant naphthoquinone in *D. rotundifolia* is 7-methyljuglone (5-hydroxy-7-methyl-1,4-naphthoquinone). Sundews contain also flavonoids, such as quercetin. We have applied HPLC-method to analyze 7-methyljuglone from sundew extracts. First we will fractionate extracts of *D. rotundifolia* with preparative HPLC to obtain pure 7-methyljuglone as a standard compound and then we are going to determine the content of 7-methyljuglone of *D. rotundifolia* ethanol extracts with HPLC.

Nutrient-poor peat bogs and bogs drained for forestry could be potential areas for sundew growth and cultivation. Our aim is also to find out the suitability of these areas for sundew collection and cultivation in the Northern Satakunta area in Finland. By mapping the presence of *D. rotundifolia* in the bogs and by sending questionnaires to the local land owners, we will chart the possibilities for sundew growing and collection.

By improving the growing methods and availability of *D. rotundifolia* together with the information of the naphthoquinone content of the biomass we hope to create better possibilities to commercial utilization of sundews in Finland.

Keywords: Round-leaved sundew, Drosera rotundifolia, naphtoquinones, 7-methyljuglone, sundew collection, sundew cultivation, nutrient poor peat-bogs, drained mires, mire vegetation

P9

Novel ocular therapeutics from the interaction of endosymbiotic *Methylobacterium* and Scots pine *(Pinus sylvestris L.)*

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All plants are inhabited internally by a vast microbiome consisting of bacteria, yeasts and fungi. These endophytic microbes are often absolutely essential for the growth, defense, and development of the plant. Endophytes provide their plant hosts a capacity to endure stress and inhabit a wider range of environments. Besides the well-studied rhizobia, facultative intracellular bacteria are rarely reported in plants. We have identified a new endosymbiosis in meristematic tissues of Scots pine (*Pinus sylvestris* L.), where *Methylobacterium* spp. live in host cells as the dominant species. The endosymbiont colonizes the aerial and below ground-parts systemically and it has capacity to increase the growth of pine seedlings to the same extent as mycorrhizal fungi. During the colonization *Methylobacterium* spp. was found to utilize the plant-produced methanol as a carbon source to further biosynthesize polyhydroxybutyrate (PHB). Upon host infection, bacterium degraded the endogenous PHB storages to yield oligomeric fatty-acid analogs (FAAs). These oligomers protected the endosymbiont from host-induced oxidative stress, enabling it to evade host defenses and colonize further tissues. The discovery of this mechanism in endosymbiotic *Methylobacterium* sp. is novel evidence of antioxidative defense in bacteria. The mechanism of PHB-based cellular protection from oxidative stress was widespread among bacteria and potentially explains how PHB-producing bacteria can sustain their cellular homeostasis in extreme conditions. Whereas the polymeric PHB is mainly found in bacteria and archaea, its monomeric unit, 3-hydroxybutyrate, exists in all living organisms. Considering that the 3-hydroxybutyrate is already actively studied for applications in human health, we tested if the structurally similar FAAs would have cytoprotective effects in human cells. In vitro stress assays on human retinal pigment epithelium cells (ARPE-19) showed that FAAs significantly ameliorate the effects of oxidative stress and increase the integrity of the retinal cells. Our results suggest that FAAs represents a potential novel therapeutic agent for oxidative stress induced ocular diseases.

P10

Arctic quality fingerprint for natural raw material (Arctic FingerPrint)

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Several new SMEs have been arisen out of the strengths and unique factors of Lapland, such as the chemical purity of nature and natural raw materials, high amount of bioactive and aroma compounds found in plants, berries and trees, and large organically-grown areas under the possession of the government. These innovative small entrepreneurs have strong intentions to export natural food and cosmetic products and break into the international markets.

The customers define the limits and the purity levels that the raw materials and the natural products of the SMEs should reach. This demands SMEs to ensure the quality control of the whole primary production chain. The confirmed quality information on the side of the natural product in the critical control points of the primary production chain would promote cost-effectiveness, marketing and export significantly. However, this demands a lot of costs. For example, the weather conditions, the changing growing seasons and the variable quality knowledge of the cultivators and collectors bring the uncertainty to the quality of the natural raw materials. In addition, the exact laboratory analyses and creating their own quality systems are very expensive because they have to be bought outside of the SME.

The primary aim of this project is to define the arctic quality fingerprint (AQF) for Lappish natural raw materials. The AQF contains all the quality parameters defined by the customer (e.g. basic composition, the amount of the certain functional compounds, contaminations etc.). It is also the base of the method which is guiding the quality level measurement of the raw material in the instant analyzer and which alarms if there are any deviations in the quality.

In this project new applications for measuring the quality of the natural raw materials are brought to SMEs in the field of natural products by testing and using instant analyzers. Among others the applicability of NIR/NIT and Raman spectroscopy with plant material are tested. The real time quality control system would help to guide the raw material stream and ensure the traceability from the forests and fields via the SMEs in all critical control points to abroad. The cost savings come in logistics and laboratory analyses because the instant quality control measurement could be done by anyone in any part of the primary production chain in few minutes. In addition, the price of the natural raw material and the product could be based on the quality, not the quantity.

P11

Future Bio-Arctic Design (F.BAD)

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Today, we are exposed to several thousands of chemicals via e.g. our living environment, cosmetics, textiles and clothing, drugs, and food. In the clothing production, almost 7000 chemicals are commonly used, most of them being harmful or dangerous to humans and nature. Harmful synthetic chemicals are e.g. applied to prevent mold growth in textiles. The research is focused on the allergies and skin irritations, but the synergy actions of these chemicals and the long-term actions are still unknown. In this Future Bio-Arctic Design (F.BAD) project, we will focus on finding and testing alternative, non-toxic plant-derived substances with protective properties to substitute synthetic chemicals used in textiles

Future Bio-Arctic Design (F.BAD) is an innovative combination of natural sciences, technology and textile design of the arctic Finnish Lapland area. The F.BAD research idea is to create smart, natural, non-toxic and health-promoting textile material by using arctic natural raw materials. The functional properties, stability and applicability of tree-, plant-, and berry-derived bioactive compounds (extracted by non-toxic and recyclable solvents) and fibres will be tested: antifungal and antimicrobial activity (mold resistance), insect repellent properties, UV-shielding and/or color anti-fading properties, the use of plant based dyes and of arctic fibres for textile production (before and after extractions). This way the material applications of natural bioactive compounds can be combined with the textile and clothing design. The research and the material development also includes smart clothes and textiles and wearable with monitoring technology, interaction of a human and technology and user experience design perspective. In addition, the future clothing research and the global megatrends are taken to account.

This interdisciplinary research is based on the strengths and unique factors of Finnish Lapland, such as the chemical purity of nature and natural raw materials, high amount of bioactive and aroma compounds found in plants, berries and trees, and large organically-grown areas under the possession of the government. The cooperation clusters in Lapland own over 40 different kinds of development environments, chemical and physical testing laboratories, real-time integrated 3D visualization environments, learning and innovation environments etc. F.BAD research group utilizes these environments in a new productive way. The goal of this research is also to advance the business actions by creating new value added use to natural raw materials.

P12

Wood- and hemp-based biochars for water purification

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Several factors such as climate change, global population increase, urbanization and industrialization have caused an exponential increase in the demand for fresh water. Due to the continuous pollution of the available water resources, cost effective materials and systems are needed to purify waste and drainage water. This study investigated the potential of wood-based and hemp-based biochars produced by slow pyrolysis for water purification.

Biomass can be converted into biochar and/or bio-oil through pyrolytic processes, such as slow and fast pyrolysis. The slow pyrolysis is mainly used for biochar production whereas fast pyrolysis produces mainly bio-oils. In slow pyrolysis process, wood is slowly heated to 300-500 °C and the heat energy breaks down the long chains of carbon, hydrogen and oxygen into smaller compounds. The products of this process include charcoal (35-40%), tar and liquids (30-45%), and gases (25-35%). The yields of the products are dependent on the raw material and the process variables, such as heating rate, final temperature, and pressure. The most common types of high-tec slow pyrolysis processes used in the industry are the Reichert retort process, the Lurgi process and the Lambiotte processes. At the University of Eastern Finland in Kuopio, a laboratory equipment for a batch and for a continuous processing in 10-100 kg scale are available.

In this study, slow pyrolysis was used to process biochars from birch bark, birch stem, spruce bark, spruce stem, oil hemp stalk and different sections of fiber hemp (root, hurd and leaves). The maximum temperature in pyrolysis was 350 ^{o}C and for comparison, additional heat treatment at 600 ^{o}C was utilized, too. Commercial activated carbon (CAC) was used as a reference absorbent. The biochar samples were ground, sieved, and then characterized using pH analysis, Fourier transform infrared (FTIR), scanning electron microscopy (SEM), x-ray fluorescence (XRF), and elemental analysis. Effectiveness of biochars in metal ion (iron, manganese, nickel, copper, and zinc), phosphate and sulphate removal was tested using Spanish drainage water containing a combination of pollutants and test water solutions prepared in the laboratory. This study showed that properly processed biochars could serve as low-cost and even better adsorbents than a commercial activated carbon for water purification. In the poster, the results are presented comprehensively and a potential for industrial scale is discussed, too.

Keywords: biochar, slow pyrolysis; water purification; wood, hemp

P13

Fermentation kinetics in bilberry (Vaccinium myrtillus L.) wine with Torulaspora delbrueckii and effects on the anthocyanins, sugars, and acids

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Bilberry (Vaccinium myrtillus L.) is a wild shrub that is widely distributed in Finland. Its berries have been traditionally consumed and have been confirmed to have a variety of health promoting benefits due to the abundance of anthocyanins and flavonols. Bilberry is usually consumed fresh because of its short shelf life.

Recently, non-Saccharomyces yeasts have been gaining importance for improving the sensory quality of wine due to their specific metabolic and physiological characteristics, including reducing alcohol content, improving aromatic complexity, as well as affecting wine's colour profile. However, non-Saccharomyces yeasts are generally not capable of competing alcoholic fermentation alone resulting from their low sugars consumption ability. Nevertheless, several studies found Torulaspora delbrueckii has higher alcoholic producing capability (6-10%, v/v) than other non-Saccharomyces strains. This study examined how fermentation with Torulaspora delbrueckii (TD291) affects the chemical quality of bilberry wine compare to Saccharomyces cerevisiae (V1116).

The bilberry juices were processed with methods of pressing, diluation, pH and suagr adjustment. Afterwards, V1116 and TD291 were inoculated to the juices at the level of 1 X 107 CFU/mL, the control was the wine without yeast. Fermentations were performed at a controlled temperature. The fermentations were completed after 40 days. Fermentation kinetics was measured by CO2 every two days, expressed in g/100mL.

Higher content of total anthocyanins was observed in control wines, followed by wines fermented with TD291 and V1116. A significant difference of total acid content was found in these three wines. The TD291 wine had significant higher content of total acid than control, but lower than V1116 wine. Due to the lower alcoholic producing capacity of Torulaspora delbrueckii than Saccharomyces cerevisiae, significant higher level of reducing sugar was found in TD291 wine. The fermentation of V1116 was more vigorous in the whole stages than the TD291 according to fermentation kinetics. This work shows that Torulaspora delbrueckii has the abilities to complete alcoholic fermentation accompanied with reduced the acid level when the sugar content is low in the raw materials.

P14

Freeze concentration in the processing of natural products

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Natural products contain valuable compounds with versatile bioactivities that can be utilized in food or e.g. in supplements and cosmetic products. These compounds are often extracted with plenty of water to achieve good yield but then the excess water needs to be removed to concentrate these compounds. Conventional evaporation using heating does not always result in high quality products if the bioactivities of these compounds are lost. A promising technology for concentration of valuable heat sensitive compounds is freeze concentration that has been used e.g. in brewing industry or fruit juice concentration. In addition to food and natural product processing freeze concentration is a potential method for other industrial sectors e.g. in waste water treatment.

Freeze concentration is a naturally occurring phenomenon, which occurs when watery solution is frozen at sub-zero temperatures. Pure water is crystallized first and these ice crystals can be removed from the remaining solution. Water soluble compounds like salts, vitamins, proteins and phenolic compounds remain concentrated in the liquid phase.

The Unit of Measurement Technology has started research “Utilization of microwaves and freeze concentration in industrial processing in Northern Finland (KryoMikro)” funded by Centre for Economic Development, Transport and the Environment, North Ostrobothnia. Freeze concentration and microwave treatment are studied by using different kinds of industrial samples including brewed products, cheese whey and natural product extracts or drinks made of e.g. berries, berry leaves, herbs, nettle or birch sap. In addition to food applications nitrogen containing landfill leachate is also investigated. The quality of the end products is studied by laboratory analysis. Equipment and processing costs for these technologies are also evaluated.

As an example of preliminary results from concentration trials of natural products the freeze concentration of chlorogenic acid containing bilberry leaf extract is presented.

Key words: freeze concentration, natural products, bilberry leaf, chlorogenic acid

P15

Chemical composition and antimicrobial activity of spruce and pine resins and some by-products

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Conifer resins have been used in traditional medicine for long time. In Finland, dried resin have been traditionally torn off from spruce (*Picea abies*) trunk and used as animal fat mixtures to treat wounds. Recently, methods to collect spruce resin directly into container have been applied in Northern Finland. Such tapped resin has the advantage to be clean from dust and any wood debris.

Monoterpenes are abundant volatile compounds in resin, which are primarily evaporating after resin exudation from bark wounds. Monoterpene composition of tapped and dried resin is consequently expected to differ. To investigate changes in terpene composition, we analyzed different types of resins by gas chromatography. Also the antimicrobial potentials (MIC, Minimum Inhibitory Concentration) against *Staphylococcus aureus* were measured with the agar dilution method.

The tested resins were: tapped and dried spruce resin collected in Lapland (Kivalo, Finland), tapped resin from Scots pine (*Pinus sylvestris*, origin Karelia, Russia), tapped resin from maritime pine (*P. pinaster*, origin SW of France), tall oil (origin Forchem, Finland) and Burgundy pitch (likely from spruce resin, France or Germany, internet shop origin).

The results showed that in all tapped resins the proportion of mono- and sesquiterpenes was ranging between 10 and 20%, while it dropped significantly in dried spruce resin, tall oil and Burgundy pitch. The most abundant monoterpene was α- pinene in all tapped resins. The second most abundant monoterpene was β-pinene in spruce and maritime pine resins but 3-carene, a potential skin irritant, was abundant only in Scots pine resin. The same diterpenes, or resin acids, were found in similar proportions in spruce or pine resins. Liquid chromatography was also used to test for the presence of phenolics; high contents of p-coumaric acid, lignans and stilbenoids were detected only in old dried spruce resin.

The MIC - values for tapped and dried spruce resin, tapped scots pine resin, tapped maritime pine resin, tall oil and Burgundy pitch were 0.6%, 0.4%, 0.3%, 0.4%, >1.0% and 0.3%, respectively.

As expected, the dried spruce resin collected from trunks contains lower amount of monoterpenes than tapped resins. Both spruce and pine tapped resins had a similar chemical composition, the major difference being a high content of β-pinene in spruce resin and a high content of 3-carene in Scots pine resin. Burgundy pitch, but especially tall oil had clearly a different chemical composition. Tall oil clearly showed the lowest antimicrobial activity of all the products tested.

P16

Keruu.fi – Our service helps to coordinate the production and distribution of organic food from Finnish forests.

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Boreal forests feature a wealth of non-timber forest products such as berries and mushrooms. Many of these are considered health promoting “super foods” with high nutritional value, antioxidants and even medicinal properties. In Finland, there is a long cultural tradition of household berry picking, which has been better maintained than in other Scandinavian countries, with over half of households participating in berry collection. Interest in berry picking and household demand for self-picked berries may be on the rise, however there may be a slow decline of harvest quantity in recent years and the number of locals picking berries for commercial sale, so there is reason to promote these activities and to engage young people especially.

There is a compelling commercial opportunity, considering that estimates of bilberry production alone are between 92 and 312 million kg of which up to 95% remain unexploited. Certifying these products as organic could enable rural inhabitants to improve their livelihoods by gaining access to urban or foreign markets through a differentiated product. According to Pro Luomu ry, the organic food sector grew by 7% in 2015 despite overall decrease in consumer spending.

The principles of organic production and labelling were initially set out by European Council Regulation 834/2007 and Commission Regulation 889/2008. The requirements for harvesting organic forest foods are more specifically defined by Evira, Finland’s authority on food safety. The area of organically certified forests in Finland is now almost 12 million hectares, which is 30% of the worldwide area. When it comes to the tracking of pickings however, a considerable amount of information needs to be maintained and shared between the various parties throughout the supply chain. Evira maintains a registry for the different roles and has a reasonable list of requirements and a presumably functioning process, however the system might benefit from a parallel service that would more directly connect the actors, perhaps all the way to the end consumer.

In Finland, the freedom to roam means that forest owners do not directly benefit from the added value generated by the organic certification of products picked by others, so there may not be enough incentive to certify their forests. Keruu.fi is a service to track forest pickings and the transmission of products throughout the supply chain with a common platform supporting each of the roles, from which a portion of the organic premium could be funnelled back to the forest owner.

P17

Antioxidant activity and phenolic content of plant leaves

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Plants are rich in secondary metabolites which protect plants from UV induced and environmental stress. These metabolites include for example phenolic compounds which have been extensively studied to transfer plants protective properties to human. Growing awareness of bioactive compounds, an increasing interest of personal wellbeing and better understanding of skin physiology and aging processes has created a demand to develop cosmetic formulations containing bioactive ingredients from plant kingdom.

In this study, the leaves of six plant species growing in Northern Finland where analysed to evaluate their utilization as a raw material for cosmetic ingredients. Chosen plant species were bilberry (*Vaccinium myrtilus*), cloudberry (*Rubus chamaemorus*), raspberry (*Rubus ideaus*), fireweed (*Chamaenerion angustifolium)*, birch (*Betula*) and *Heracleaum sibiricum*, a subspieces of common hogweed (*Heracleum sphondylium*). Dried plant leaves were extracted with ethanol-water. Antioxidant activity ORAC (oxygen radical absorbance capacity), total phenolic content (Folin Ciocalteu), quercetin, chlorogenic acid, ellagic acid (including ellagic tannins) and anthocyanins were analysed from extracts.

Bilberry and birch leave extracts had the strongest antioxidant activity and the highest phenolic content. High antioxidant activity was found also in cloudberry leave extract which was rich in ellagic acid (ellagitannins). In addition, comparatively high level of phenolics was detected from cloudberry, as well as from fireweed leave extract. Bilberry, common hogweed and birch leave extracts had substantial amounts of quercetin and chlorogenic acid. In conclusion, studied leaves from various plant species are an attractive source of bioactive compounds for cosmetic ingredients when considering their chemical content and antioxidant activity.

Keywords: plant leaves, ORAC, phenolic compounds, cosmetic ingredient

P18

Autumn leaves - upgrading park and garden waste to useful chemicals for industry

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Natural pigments and antioxidants, as well as compounds with antimicrobial activity are highly demanded by various industrial sectors. Colourful fallen leaves covering ground every autumn derive their orange and yellow colours from carotenoids, red to purple colours from anthocyanins and tones of brown from tannins and other phenolics. In addition, the leaves contain lignin, carbohydrates and protein.

Very little use has been made of fallen leaves so far. They are either left on the ground, composted or incinerated resulting to growing carbon dioxide load. VTT has developed sustainable processing technologies for harvesting and extraction of autumn foliage prioritizing the production of natural pigments. The target is to upgrade leaf material by converting biomass and metabolites into natural pigments, high-value carotenoids, proteins and novel ingredients with bioactivity.

Special attention is paid to the environmental friendliness of the overall process and the safety of the compounds produced. The leaves are gathered in gardens and parks, dried and ground and extracted. The chemical composition of leaves varies largely between different tree species effecting strongly on pigment composition in the extracts. Added value is obtained by processing the autumn leaves of certain tree types only, thereby producing well-defined compounds.

The primary applications developed for the pigmented extracts are natural colorants for dying e.g. of textiles. In addition, coloured compounds with bioactivities can be exploited by cosmetic, hygiene and pharmaceutical industries. Extraction residue, which covers the main leaf biomass after extraction process, is high in nutrients and suitable for soil improvement in home gardens, as well as for growing mushrooms. On the other hand, the residue biomass can be further processed resulting to products with antimicrobial activity usable e.g. for hygiene products. The extraction residue is rich in the carbohydrates, and the potential application evaluated is the production of protein-rich feed for livestock by fermentation of this residual biomass.

P19

Efficient cyclone drying of bilberry, cloudberry, and blackcurrant press cake from juice production

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Food industry generates many byproducts that can be processed into valuable materials instead of becoming waste. The berry juice industry generates byproducts like press cake, which is very often discarded as waste. Drying press cake can lead to deterioration of the material due to thermal degradation of bioactive compounds. Efficient drying methods that do not significantly affect the raw material quality are needed. This contribution shows results from drying of press cake coming from bilberry (*Vaccinium myrtillus*), cloudberry (*Rubus chamaemorus*), and blackcurrant (*Ribes nigrum*) in a bench-scale cyclone dryer. This drying technology allows for efficient drying at low temperatures and short residence times.

The experiments were performed according to a two-level factorial design in three factors (2^3). Controlled factors were inlet air velocity (60-110 m/s), feeding rate (2-6 Kg/h), and inlet air temperature (40-90 °C), and uncontrolled factors were ambient temperature, ambient RH, and raw material dry matter. Three replicated midpoints were also included, resulting in a total of 11 runs for each raw material. A high frame rate video camera capable of recording at speeds of up to 240 frames per second was used to film the raw material stream inside the cyclone, and the residence time of individual particles was determined by the aid of a video editing program.

The results showed that inlet air velocity and temperature were the main factors that determined the moisture content of the product, independently of the type of feedstock used. The dry matter increased with increasing inlet air velocity and temperature and decreased with increasing feeding rate. Efficient drying can be achieved at temperatures around 80 °C when using inlet air velocities in the order of 110 m/s. A side effect of the cyclone process is the separation of sticks and leaves from the berries. For the best experimental conditions that resulted in the highest water removal, i.e inlet air velocity of ~110 m/s, temperatures of ~90 °C, and feeding rate of 2 Kg/h, the dry matter of the processed materials went from 24 to 85% for bilberry, 36 to 68% for cloudberry, and 44 to 80% for blackcurrant. The final moisture content is mainly represented by water contained in seeds, which are difficult to dry completely. The residence time of the feedstock was estimated to be around 3 to 4 s, which probably would help to preserve heat sensitive bioactive compounds like anthocyanins.

P20

Extraction of bilberry press cake for obtaining antioxidants

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Bilberries (Vaccininum Myrtillus) grow in Northern Europe and they are sold as berries and juices, but they are also used as extracts for the healthcare and cosmetics industries. The result of juice production is a press cake that is a rich source of polyphenols (anthocyanins) that are acknowledged as useful antioxidants. Therefore it is important that extraction of the bilberries for obtaining antioxidants is done in an optimal fashion. Ethanol is the least poisonous of all organic solvents and was therefore used.

A number of extraction methods for obtaining an optimal amount of antioxidants were tested: (1) traditional extraction (2) a novel rotating bed reactor (RBR), (3) a two-phase RBR system using phosphate (4) a two phase RBR system using sulphate and (5) microwave extraction. All methods were tested on the same press cake by experimental designs and the responses were (a) polyphenol concentration in the extract using Folin Cocialteu reagent and VIS spectrometry (b) VIS-NIR spectrometry on the extract and (c) GC -MS analysis for measuring individual anthocyanins (Delphinidin, Cyanidin, Petunidin, Pelargonidin, Peonidin and Malvidin). Measurements (a) and (b) were done as a function of time during the extraction but (c) was only measured on the final extract.

The experimental designs allowed interpretation of regression coefficients and construction of response surfaces for finding an optimum. The multivariate VIS-NIR spectra allowed a multivariate interpretation.

General conclusion: RBR (2) works better than traditional extraction (1). Two-phase extraction (3) and (4) allows separation of sugars in the salt solution phase while the anthocyanins remain in the ethanol phase. Microwave extraction (5) is very flexible in its parameters for obtaining optimal anthocyanin amount and least byproducts. Methods (2) and (5) can easily be scaled up to pilot or industrial scale.

P21

Organic wild collection in forests

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Wild products collected from nature are favorable, sustainable raw materials as these products grow without inputs. In addition to providing nourishment, wild products will be a source of innovative raw materials for, among others, welfare products and cosmetics. Wild forest raw materials and products may be sold as organic if the whole production chain follows organic supervision. The organic certification label in collected products guarantees the product quality and the origin.

There is approximately 26.2 million hectares of forestry land In Finland where berries, mushrooms, herbs and other non-timberd forest products (NTFP) can be collected. Nearly half of this area, approximately 12.2 million hectares, is certified as an organic picking area. In the future, the organic forest area can be doubled in size due to the extremely low use of chemical fertilisers or pesticides in Finland. At the moment, the bulk of the organic picking area is located in Northern Finland.

In Finland lingonberry (Vaccinium vitis-idaea), bilberry (Vaccinium myrtillus) and cloudberry (Rubus chamaemorus) are the most important commercial berry species. Many other wild-collected products, such as wild mushrooms, herbs and birch sap could be collected and used as native products and for further product development in considerably higher amounts.

In Southern Finland there are more private forest owners than in Northern Finland. An inquiry was made in Etelä-Savo to the forest owners for surveying the forest owners' attitude to the NTFP and organic certification. The adding of the utilising of collecting products was considered as a good matter and it was seen that the organic certification would give surplus value to the products of the forest. Also a possibility to certify also trees, not only collecting products, was hoped for. On the other hand, it was feared that the certification caused more costs, bureaucracy and restrictions on the forestry.

P22

Citizen science in nationwide wild berry monitoring

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It has been estimated that 50 – 60 % of Finns pick wild berries. This enthusiasm is a cross cutting phenomenon through all age classes, though the senior citizens are the most active berry pickers.

Due to desire for wild berries, Natural resources institute Finland (Luke) have been giving berry harvest forecasts since 90´s. The forecasts have been based on monitoring sites forming a nationwide network. So far, flowers, raw berries and ripe berries have been counted from the sites, mostly by field workers of research institutes. However, maintaining a comprehensive monitoring network has been a major challenge as reliable forecasts require numerous monitoring sites.

Establishing and maintaining monitoring sites is rather straightforward task, although meticulousness and exactitude are required to guarantee the reliability of the data generated. On 2017, berry monitoring crowdsourcing was initiated in cooperation with the Finnish 4H organization which has more than 200 clubs throughout Finland. This offers a good base for renewed monitoring network.

After contacting the local 4H clubs, 4H organization recruited more than hundred 4H members to the monitoring work. Participants of the network were trained with written instructions and webinars. Altogether 78, 77 and 45 monitoring forests were established for bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-ideae*) and cloudberry (*Rubus chamaemorus*), respectively. Monitoring data was relayed to Luke by a map-based survey tool, Harava (“Rake”), which integrates responses with spatial data and can be used with a smartphone.

As a result, Natural resources received 1000 berry monitoring results from 200 sites with a cost equaling roughly cost of 3.5 working months of a Luke´s field worker. The gain is quite remarkable, as an individual field worker is seldom able to monitor more than two forests during a working day due to distances between the sites. In addition to generation of field data the crowdsourced berry monitoring serves the youth activation and environmental education goals of 4H organization. The observers were mostly 14-17 years of age, and they also received a small fee for their work. In future, the crowdsourcing will be expanded so that every Finnish resident can volunteer in the monitoring network while an organized partner organization, like 4H, maintains the core of the network.

P23

Kuehneromyces mutabilis, ediple mushroom with potential bioactive properties

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Kuehneromyces mutabilis is widely distributed wood-rotting fungus in European countries, North America, Australia and Asia. It is tasty and commercially potential mushroom species. Trials to cultivate this mushroom have been reported for example in Finland by J. Issakainen (Turun Ammattikorkeakoulun raportteja 216, 2015). We aimed to study the suitability of this mushroom for cultivation on nutrient poor, low-productive drained peatland forest, where wood production is not possible in a profitable way and new ideas to utilize these areas are needed. In addition we aimed to screen the bioactive properties of *K. mutabilis* to evaluate the potential to boost the development of high-value products of this mushroom.

We isolated *K.mutabilis* strains from fruit bodies and sequenced the DNA using ITS1 and ITS4 primers to make sure of the species used for inoculation purposes. Mycelium inoculums from three fungus strains were grown on a mixture of Hagem agar and birch sawdust. One commercial strain was included in the trial. Inoculums were placed into holes which were drilled into birch stumps and blocks. Inoculation was performed in June 2016. The study plot was located in birch forest on a drained peatland in western Finland.

To study the antioxidative properties of the *K.mutabilis* fungus tissues were ground and extracted with hot water and tested with oxygen radical absorbance capacity (ORAC), H_2O_2 scavenging (SCAV) and ferric reducing antioxidant power (FRAP) assays. *K. mutabilis* showed antioxidative potential in SCAV-assay, whereas low bioactivity was seen in ORAC and FRAP assays.

We also used recombinant bacterial strains to screen antimicrobial effect on constitutively light generating strains *Eschericia coli K12* and *Saccharomyces aureus 8325-4* and genotoxic effects on *E coli* DPD2794 mutant. *K.mutabilis* extracts showed antimicrobial potential with all three microbial biosensors.

In our field study, the inoculum was shown to grow successfully. One year after the inoculation development of fruitbodies in the birch stumps and blocks was not yet seen and shall be followed longer period.

The culinary properties of *Kuehneromyces mutabilis* together with the potential bioactive efficiency create increasing interest in cultivation of the mushroom and new product development.

Keywords: Kuehneromyces mutabilis, bioactive properties, cultivation

P24

Cultivation and antioxidative properties of pakuri (Inonotus obliquus) on low-productive peatland forests

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Pakuri (chaga mushroom, *Inonotus obliquus*) is a wood-rotting fungus of birch and other deciduous trees. The sterile sclerotial conk on the trunk of living tree has been used as folk medicine usually in the form of tea. Even today an increasing number of people use Chaga tea as refreshment with or without health care purposes.

Pakuri produces a large variety of biologically active substances including e.g. phenolic compounds, melanins, and triterpenoids. Components for antioxidant, antitumoral, and antiviral activities as well as for improving human immunity have been found in pakuri.

In order to ensure in the future the constant supply of raw material for entrepreneurs of pakuri products, and to get additional incomes from nutrient poor, low-productive, downy birch dominated drained peatland forests a non-sterile cultivation protocol for pakuri was developed. We inoculated altogether 90 downy birch trees by planting a small piece of mycelium containing agar into hollows drilled into the trunk. We used three different pakuri strains in order to study the differences between the strains in the success of infection, growth and antioxidative properties.

Pakuri mycelium pure cultures were performed by cutting small pieces from the conk and laying them on Hagem agar plates after a short bath in H_2O_2. Identification of the isolated fungus strain was confirmed by sequencing the amplified ITS-region of the fungal DNA by using ITS1and ITS4 primers.

There can be seen a couple of clearly visible pakuri conks three years after the inoculation. The biggest conk found is ca. 10 x 20 cm large. However, at least in the early phase of infection, the formation of conks concentrates strongly on a particular pakuri strain. According to our first results, the differences in infection properties between the strains of pakuri emphasize the importance of selection of the inoculants for the cultivation before establishment of large scale field cultivations.

Various assays, H2O2 scavenging, oxygen radical absorbance capacity (ORAC), ferric reducing antioxidant power (FRAP) and total phenolic content (Folin-Ciocalteu) are used to screen the antioxidative properties of the conks and pure culture mycelium of pakuri. We will test also the antioxidative properties of the first conks from the inoculation experiments and compare those with the mycelium grown on the pure culture. These results will elucidate whether it is possible to affect the bioactive properties of the cultivated conks by selection of the inoculants.

P25

Living luminescent bacterial biosensors as an indicator of bioactivity of non-timber forest biomasses

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When using intact living biosensors, both bioactivity and bioavailability of a chosen sample material can be detected simultaneously in a simple, cost-effective and rapid manner. We are using recombinant bacterial strains modified to produce a luminescent light signal in the presence of oxidative or antimicrobial material. The test can, however, also be reversed in a way that it measures antioxidant capacity of the sample. We have successfully used the methodologies for samples such as Sphagnum mosses, edible mushrooms and endophytes as well as selected berries and bark and needle samples of coniferous trees. The produced luminescent light signal is easy to measure and quantify in real-time and in a continuous manner by using the developed microplate methodologies.

The luminescent light signal can also be visualized and photographed from a living biological source using an in-vivo optical bioluminescence imaging system (Xenogen IVIS). The equipment produces most impressive images with vivid colors that correspond to different luminescent light signal levels and thus directly to the bioactivity of the sample material. The method is under development, as the luminescent light signal data is at the present not easily comparable between images and between spots of an image. The imaging system is being modified in a way that it produces the data in a table form and thus eases the comparability and reporting of the results.

We are also developing a method to screen the UV protection ability of natural products and we have been able to see reproducible and dose dependent results using control substances and some known UV shields. The test method is now to be optimized for forest-based biomasses. The microplate technique in process is more precise and easily constructed without the need for time-consuming pre-handling and possible requirement of robotic tools as with the conventional methods used up to date. The sample material to start with will be fungal, Sphagnum moss and conifer bark samples and the test can be used for nearly limitless selection of samples.

Bacterial biosensors are easy, cost-effective and reliable producers of bioactivity data and are only marginally exploited up to this date. We have developed easy tools and test methods that can be utilized in the search of bioavailable and bioactive products of forest.

P26

Chemical Composition of the Water Extract of Young Spruce (*Picea abies* (L.) Karst) Shoots

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Young shoots of spruce are a natural resource that have been used as a remedy or a food ingredient for a long time. Although, it cannot be harvested from the forest without the permission of the landowner, it could be exploited more. Almost third of Finnish forests resources is spruce, forming enormous reservoir for the spruce shoots and more refined spruce shoot products.

Lactic acid bacteria is one of the most, if not the most, used group of microbes in the food industry. In our earlier growth experiments the water extract from young spruce shoots had an enhancing effects in the growth of some strains of Lactobacillus species. Particularly, Lactobacillus plantarum grew better and had shorter lag time, when growth medium contained spruce shoot extract. To apprehend better, what could generate an effect seen with the growth of the bacteria, we analyzed the chemical composition of the water extract of the spruce shoots.

For the evaluation of the chemical composition of the spruce shoot water extract chromatographic, capillary electrophoretic and spectrophotometric methods were used. Sugars and sugar alcohols were measured with the capillary electrophoresis (CE), glucose and inositol respectively being of most abundant. Also non phenolic acids and inorganic cations were analyzed with the CE. Quinic acid was the main non phenolic acid detected, and of the inorganic cations K, Mg, Ca, Ni, Zn and ammonium were recognized from the extract.

Antioxidant capacity (reduction potential) of 772mg GAE/L was measured for the extract using spectrophotometric method of Folin-Ciocalteu. To analyze phenolic compounds, chromatographic methods developed for the detection of catechins, proantocyanidin, phenolic acids and stilbenoids were utilized. Main catechins in the water extract were the catechin and epicatechin. Type B dimers were the most apparent of the proantocyanidins. The extract contained several benzoic and cinnamic acid derivatives, but protocatechuic acid and p-coumaric acid were the most apparent ones. Of the stilbenoids trans and cis forms of piceid, sugar derivative of resveratrol, and astringin were the most abundant.

Future research will focus on, whether Lactobacillus bacteria will metabolize one or more of these detected compounds found when in growth with the extract.

Keywords: Spruce shoot, water extract, chemical composition, phenolic compounds, Lactobacillus.

P28

Analysis of slow pyrolysis liquids by using NMR methods

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Wood, the most common organic material on earth, is a hard carbon-neutral renewable fibrous material containing ca. 40 % of cellulose fibers, 30% of hemicelluloses, 25% of lignin, 4 % of extracts (resin) and 1% of other components. Typical elemental composition of wood is about 50% of carbon, 43% oxygen, 6% of hydrogen and only 1% of nitrogen. Traditionally wood is used as a construction material and fuel as such or after pyrolysis to charcoal. Recently, also by-products of different wood treatment processes (e.g. pyrolysis) have become more and more important because of green chemistry demands[1].

Among the traditional pulp production, there is several methods to produce small molecules from wood material, like extractions with water or controlled heat treatment (pyrolysis) under different conditions. Flash pyrolysis, operating at >500^{o}C, is a common industrial process used to produce fuels, but these liquids are complex mixtures containing thousands of compounds. On the other hand, slow pyrolysis operates at significantly lower maximum temperatures (<500^{o}C) producing liquids which are far less complicate.

The contents of small molecule fractions from woods have been analysed by several methods. The most common techniques are gas and liquid chromatography combined to mass spectrometry[2]. Fourier transform infrared (FTIR) spectroscopy has been utilized to study functional groups and gel permeation spectroscopy (GPC) to find out molecular weight distributions[3]. However, mostly these methods are limited to known compounds.

On the other hand, NMR spectroscopy is the most efficient tool to analyze chemical structure - even previously unknown molecules or stereochemistry, of small molecules (M.W. < 1000 g/mol) if millimolar amount of sample is available. In general, ^{1}H and ^{13}C NMR spectroscopy have been widely used to analyze unknown components from various wood extract[4], but profiling of functional groups and single components from distillate mixtures is unknown. However, nowadays NMR spectroscopy offers good possibilities to analyze even complicated mixtures when multidimensional measuring techniques are combined to effective spectral analysis tools and automated processes.

In the poster some typical examples of slow pyrolysis samples from Norpyro TEKES project at different temperatures is presented including analysis of most common compounds, like acetic acid, furfural, methanol and methoxyphenols.

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P29

Hericium coralloides: a potential successor crop to Inonotus obliquus

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The cultivation of the sterile cankers (pakuri) caused by the polypore fungus *Inonotus obliquus* (Fr.) Pilát on birch (*Betula sp.* L.), by means of artificial inoculation on living trees, is an emerging mushroom-based agroforestry practice in Finland. At the moment, the only proposed use for the round wood after the last harvest of the pakuri-cankers is as firewood.

In boreal forests, the succession of decay fungi in dead wood is partly driven by the primary species occupying the woody tissues. A typical successor species of the *I. obliquus* is coral tooth fungus, *Hericium coralloides* (Scop.) Pers. Fresh mushroom yields of up to 10 kg on a single birch trunk are known for this edible species.

In this study, the possibility of increasing the value of *I. obliquus*-inoculated round wood for mushroom-based agroforestry is investigated. The question of whether vegetative growth and fruit-body yield of *H. coralloides* is affected by the presence of *I. obliquus* in the substrate was studied. The experiment was carried out by inoculating *H. coralloides* on wood substrate. Birch chips were sterilized in an autoclave, and inoculated with either *H.coralloides* alone, or together with *I.obliquus*. In addition, sterilized substrate decomposed by *I. obliquus* was tested.

The results indicate potential of *H.coralloides* as a successor crop for *I.obliquus*, and serve as baseline information for future trials to develop a cultivation practice for *H.coralloides.*

This study was funded by EU Rural Development Programme for Mainland Finland 2007-2013 as part of the project SieVi - Mushroom cultivation as a practice of agroforestry based bio-economy.

Keywords: Hericium coralloides, Inonotus obliquus, Agroforestry, Mushroom cultivation, Non-Timber Forest Product

Author index

KEYNOTE ABSTRACTS = K
ORAL ABSTRACTS = O
POSTER ABSTRACTS = P

Järvenpää	Eila	O5
Jääskeläinen	Anna-Stiina	P18
Kaarniranta	Kai	O6, P9
Kadlec	Jiří	O24
Kallio	Heikki	K4
Kallio	Tuija	P6
Kanniainen	Teija	O20
Karp	Matti	P23, P25
Karppinen	Katja	O3, O4
Kauppinen	Anu	P9
Kelanne	Niina	P7
Keränen	Essi	O16
Kilpeläinen	Harri	O7
Kilpeläinen	Pekka	P6
Klum	Jimmie	P20
Konttaniemi	Heikki	P11
Korhonen	Jenni	O16
Korpela	Leila	P8
Korpinen	Risto	O5, P11
Koskela	Ali	O6, P9
Koskimäki	Janne	P9
Kunnas	Susan	O5, P10, P11
Kuovi	Anu-Teija	P23, P25
Kurttila	Mikko	O7, O19, O20, O23, P4, P22
Kuure	Sari	P5
Laakkonen	Mika	P11
Laaksonen	Oskar	O18, P7, P13
Lappalainen	Reijo	O16, P12, P28
Larmo	Petra	O8
Laurila	Marika	P11
Linnakoski	Riikka	P2, P29
Liu	Shuxun	P13
Luoma	Jaana	O16
Lähdesmäki	Merja	O11
Malinen	Hanna-Liisa	O11, P14, P17
Maradani	Bhavani Shankar	O10
Marques	Marlene	O23
Martinussen	Inger	O3, O4, O21
Martz	Françoise	P15
Matilainen	Anne	O11
Merilä	Paula	O12
Miguel	Sergio de	O23
Miina	Jari	O7, O19, O20, P4, P22
Misikangas	Katja	P10
Moon	Thomas	P16
Mossing	Torgny	P19, P20

Muilu-Mäkelä	Riina	P23, P25
Mäki	Marianne	P14, P17
Mølmann	Jørgen	O21
Möttönen	Veikko	P2
Naskali	Arto	O13
Nguyen	Nga	O3
Nohynek	Liisa	O15, P18
Nuutinen	Ana	P11
Nyström	Josefina	P19, P20
Oksman-Caldentey	Kirsi-Marja	O15
Partanen	Birgitta	P21
Pasalodos-Tato	Maria	O23
Peltola	Rainer	O14, P4, P15, P22
Peräniemi	Sirpa	P12
Pesälä	Ossi	O24
Pietarinen	Heidi	P11
Pihlava	Juha-Matti	P10
Poikulainen	Emmi	P25
Pukkala	Timo	O19
Puljula	Elina	O16, P28
Purpure	Liva	O3
Puupponen-Pimiä	Riitta	O15, P18
Raatikainen	Olavi	O16, P12, P28
Raitanen	Jan-Erik	O5
Raittola	Auri	O18
Rajasekaran	C	O10
Raji	Habeeb	P12
Ranganahall	Harisha	O17
Raninen	Kaisa	O16
Reinisalo	Mika	O6
Remes	Janne	O3
Ritala	Anneli	P18
Salami	Ayobami	P12
Salminen	Olli	O7
Salo	Kauko	P22
Sami Lieskoski	Sami	O9
Sánchez-González	Mariola	O23
Sandell	Mari	O18
Sandström	Camilla	K2
Santala	Ville	P23, P25
Sarjala	Tytti	O5, P8, P23, P24, P25
Savonen	Savonen	P23
Selenius	Selenius	O16, P12, P28
Seppänen-Laakso	Tuulikki	P18
Setty	Siddappa	O10
Silvan	Niko	P8, P23, P24
Sipola	Reeta	P11

Tahvanainen	Veera	O19, O24
Tienaho	Jenni	P23, P25
Tikkanen	Jukka	O20, O24
Tolonen	Tiina	P5, P26
Tolvanen	Anne	O12
Tom Lillhonga	Tom	O9
Tomppo	Laura	P12
Trivedi	Priyanka	O3
Trygg	Jani	O1
Turtiainen	Marjut	O20
Uleberg	Eivind	O3, O4, O21
Uusitalo	Marja	O14
Uusivuori	Jussi	O22
Vaara	Matti	O24
Vacik	Harald	O23
Vanhanen	Henri	O24, P2, P4, P29
Vepsäläinen	Jouko	O16, P12, P28
Vervoort	Marieke	O21
Vesala	Päivi	O3
Veteli	Pyry	P2, P29
Vikström	Simon	P20
Vilppo	Teemu	O16, P12, P28
Vilpunaho	Tommi	O16
Virtanen	Veera	O15
Virtanen	Vesa	P5, P6, P14, P17, P26
Wolfslehner	Bernhard	O23
von Wright	Atte	O16, P26
Vuorikari	Kasperi	P12
Väänänen	Juha	O3
Yang	Baoru	P1, P7, P13
Yang W	Wei	P7
Zoratti	Laura	O4

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