



NOVELBALTIC

Market driven authentic non-timber forest products from the Baltic Sea region

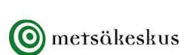
Project report

Research and development infrastructure and industry needs

Work Package 2

Activity A2.1

Output O2.1



Annotation

A detailed survey of the infrastructural needs for research infrastructure of academia and SME to promote new non-timber forest products is carried out. A survey of R&D equipment available to NovelBaltic project partners has been conducted and availability of facilities in project partner laboratories (such as HPLC, GC in different laboratories as well as specialised equipment such as freeze dryers, CO₂ extractors, Raman and NIR spectrometers) has been evaluated to prepare the NovelBaltic service platform. The existing capacity of the R&D laboratories is satisfying needs of industries in the Baltic Sea Region. The laboratories of project partners are interested and ready to provide services to industry for quality characterisation and authenticity testing as well as for upscaling from R&D lab scale to pilot and industrial scale. Many laboratories are considering investments (e.g. pilot scale extraction, biomass characterisation) to enhance the non-timber forest products/natural products development opportunities. During this activity, in cooperation with other project partners, a questionnaire was elaborated and a survey was done with an aim to identify the needs in respect to research and development infrastructure in the Baltic Sea region countries and Norway at present and in future and to match the need of industry and emerging markets in SE Asia and China to support: a) creation of new products based on NTFP; b) support development of authenticity and quality control methods; c) develop standardization methods of NTFP; d) training at universities and research on NTFP. The survey includes needs of enterprises and R&D capacity analysis of project partner organisations. Results of the survey reveal current high capacity of academic institutions and interests of industry, but at the same time identify the bottlenecks and support identification of solutions to solve problems. Results of the survey thus help to develop research and development infrastructure platform and strengthen the cooperation between industry and academia supporting further integration of research institutions in solving of applied problems. The services can be adjusted to match the needs of market demand in Asia and to support the development of novel non-timber forest products including the development of novel test methods. The survey results are used to develop the NovelBaltic R&D platform and the platform will help for the development of novel authenticity and quality testing methods based on the need of industry partners.

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1. Non-timber forest products (NTFP) for development of bioeconomy

Europe is setting course for a resource-efficient and sustainable economy. The goal is an innovative and low-emissions economy, reconciling demands for sustainable agriculture and fisheries, food security, and the sustainable use of renewable biological resources for industrial purposes, while ensuring biodiversity and environmental protection¹. From perspective of development of bioeconomy it is important to consider all kinds of bioresources and thus largely neglected are non-timber forest products. Non-timber forest products include berries, mushrooms, herbs and special non wood forest products like bark, sap and resin or lichen. Use of NTFP's belong to the bioeconomy sector and is actively supported accordingly to EU sustainable development strategies in the Nordic, Baltic countries and elsewhere. The development of NTFP production and applications are largely oriented towards production of health promoting food and bio-based pharmaceuticals, cosmetics it creates job opportunities in rural areas, since manufacturing or refining of these products is economically most efficient close to place of origin, forests and farmlands. Actualities to develop NTFP production and applications is reflected in the national bioeconomy development strategies of countries of the Baltic Sea Region. For example, according to the Finnish bioeconomy strategy, the value of bioeconomy should grow from 60 billion € to 100 billion € by 2025². According to the latest Finnish NTFP sector report (5/2017), there are more than 750 enterprises in Finland and the business value is over 300 million €. There are political initiatives to promote development of bioeconomy in the northern areas based on bioresources. The focus is on integrated biorefinery; one raw material to several products, and there is a need to develop 1) access to raw materials 2) technology and 3) processing.

Food sector and agriculture are the largest share of Lithuanian bioeconomy and needs for food security ensures the priority of the food sector³. In Latvia the strategic goals of the bioeconomy development are divided into three main groups: 1) advancement and retention of employment in the bioeconomy sectors for 128 000 people, 2) increasing the value added of bioeconomy products to at least EUR 3.8 billion in 2030, 3) increasing the value of bioeconomy production exports to at least EUR 9 billion in 2030⁴. Estonian bioeconomy covers almost all industry sectors, mostly based agriculture and forestry covering e.g. food, feed, chemical, biotechnology⁵. In the case of berries more than 90% is left in the forests annually. Global cultivated blueberry export between 2001 and 2010 has grown from over 53,000 tonnes to 113,000 tonnes and the value has grown from 119 million \$ to over 300

¹ <https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy>

² <https://www.bioeconomy.fi/facts-and-contacts/finnish-bioeconomy-strategy/>

³ [https://eimin.lrv.lt/uploads/eimin/documents/files/Inovacijos/bioekonomikos%20studija/Lithuanian%20Bioeconomy%20Study_EN\(1\).pdf](https://eimin.lrv.lt/uploads/eimin/documents/files/Inovacijos/bioekonomikos%20studija/Lithuanian%20Bioeconomy%20Study_EN(1).pdf)

⁴ https://www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/01/46/58/E2758-LatvianBioeconomyStrategy2030.pdf

⁵ http://www.bioeconomyforum.llu.lv/images/llar_Lemetti_4_Governance.pdf

million \$⁶. Annually, millions of kg of wild berries from Baltic countries are exported as frozen berries to Asia and Central Europe for further refining⁷. Berries are often imported back to the Baltic countries as refined products. In Finland annual crop of berries varies between 500 – 1,000 million kg, and typically only 15 million kg is utilized by the industry. In 2014 the bilberry crop was 5.9 million kg and the next year the crop had increased to 7.6 million kg⁸. The world market for bilberry extract is estimated to be 180 tonnes. The market value in form of pills and capsules is more than 700 million € annually⁹. The value of NTFP's like berries could be a lot higher if biomass was refined to higher value products, which would create jobs in rural areas.

Globally the Nordic/Baltic NTFPs are valued highly because they are often organic and wild and they are regarded as authentic, safe and the concentrations of valuable components are higher than in plants grown in e.g. southern parts of Europe. The high quality has also been linked to the climate and genetics, which are involved in the branding of NTFP from this region¹⁰.

An example of NTFPs of importance for national economies are the different bog and forest berries – blueberries, cranberries, bilberries and others (Figure 1, 2). The situation in two countries (Latvia and Finland) demonstrate the importance of the “berry business” and the increasing trends of berry production and export.

⁶ <https://www.tridge.com/intelligences/bilberry/production>

⁷ <https://www.npr.org/sections/thesalt/2015/09/16/440643854/asian-countries-have-nordic-berry-fever-and-finland-cant-keep-up?t=1572683089685>

⁸ <https://www.internationalblueberry.org/2017/09/29/an-overview-of-global-blueberry-production-in-2016/>

⁹ <https://www.tecnologiahorticola.com/blueberry-europe-market-change/>

¹⁰ Foster, Steven, and Mark Blumenthal. "The adulteration of commercially bilberry extracts." *HerbalGram* 96 (2012): 64-73.

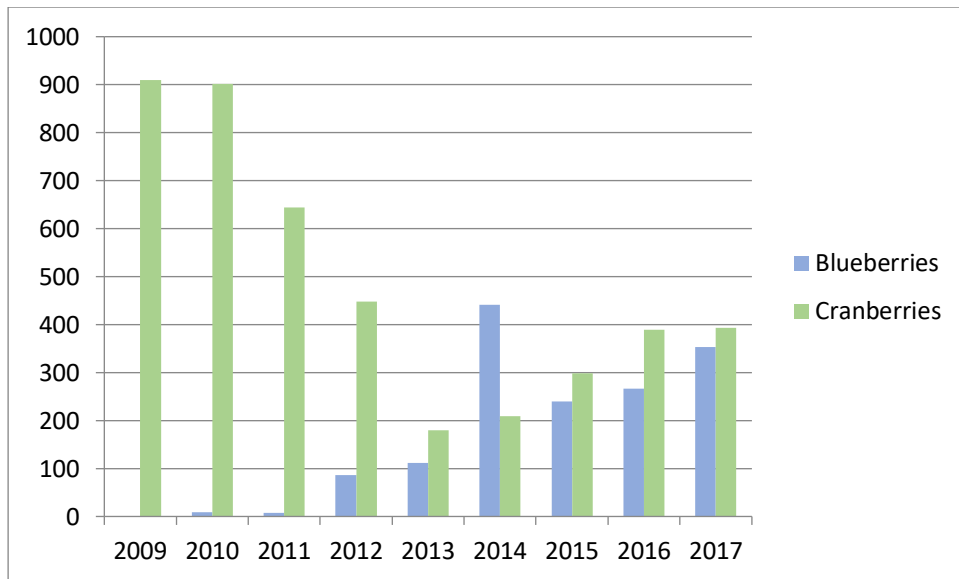


Figure 1. Production quantity of blueberries and cranberries (tonnes) in Latvia according to FAOSTAT data.

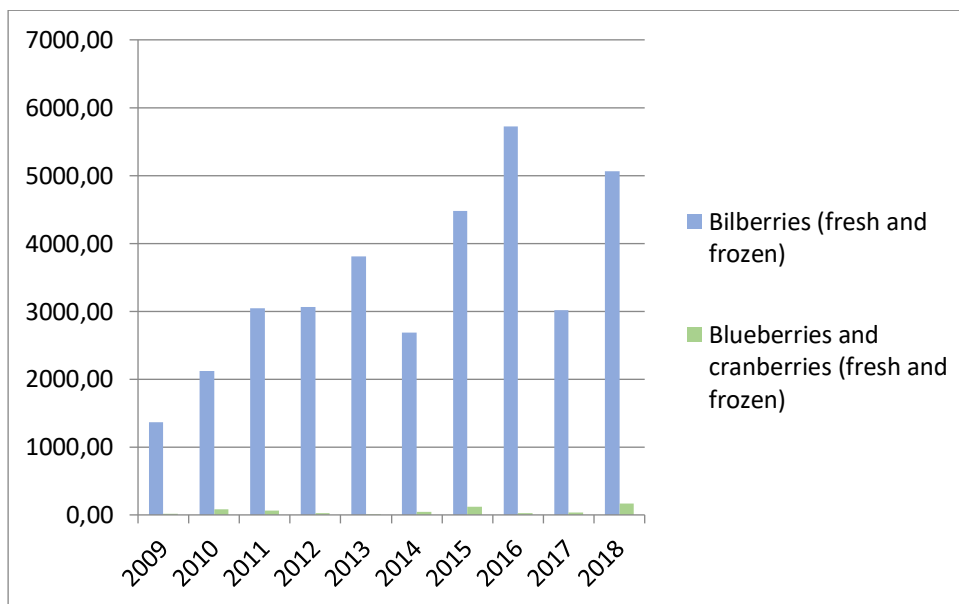


Figure 2. Export of blueberries and American cranberries (tonnes) from Latvia according to the data of the Ministry of Agriculture of the Republic of Latvia. Blueberries - *Vaccinium corymbosum* L., American cranberries - *Vaccinium macrocarpon* L.

Despite some fluctuations in berry production and export (Figure 3) the trend of their production/sampling is evidently increasing the Baltic Sea region countries. In Latvia the forest berries, bilberry and lingonberry are exported to Finland, China, Italy and imported from Belarus, Ukraine, however, these statistics are not gathered by government institutions, therefore the traceability of these products in Latvia is poor and very difficult in most cases.

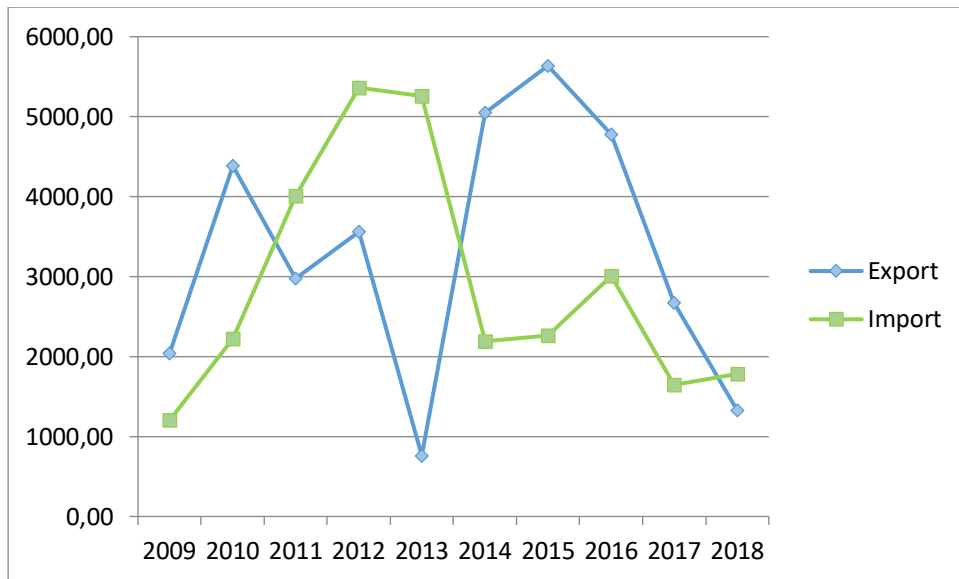


Figure 3. Export and import of bilberries, fresh and frozen (tonnes) in Finland according to FAOSTAT data.

Bog and forest berries are the most evident NTFPs of interest for further processing and development of new businesses (Figure 4). However, there are many other NTFPs, prospective for further processing and use. Just one example: *Sphagnum* mosses: probably the most abundant mosses in Northern Europe in wet ecosystems. Presently the *Sphagnum* mosses are relatively rarely used, however also their application could be wide, including medicine, food preservation, insulation materials and others¹¹.

¹¹ Klavina, Laura, Gunta Springe, Vizma Nikolajeva, Illia Martsinkevich, Ilva Nakurte, Diana Dzabijeva, and Iveta Steinberga. "Chemical composition analysis, antimicrobial activity and cytotoxicity screening of moss extracts (moss phytochemistry)." *Molecules* 20, no. 9 (2015): 17221-17243.



Figure 4. Non-timber forest products of potential interest for studies of properties, applications and development of new products.

2. Study on business needs related to NTFP processing in partner countries: science, testing, and R&D infrastructure



NTFPs provide a new kind of business potential and require new knowledge, development of new products, and their quality control. Thus, it is important to understand the needs of the enterprises interested in the development of products from NTFPs. So far, the needs of businesses interested in the NTFPs in the Baltic Sea Region have not been studied, and one of the aims of the project is to understand the needs of industry and to prepare suggestions on how to meet them in optimal way. The aim of the study is to identify the needs in respect to research and development infrastructure in partner countries, both at the present and in the future. The aim is to match the needs of industry and emerging markets in South East Asia and China and to support: a) the creation of new products based on NTFPs; b) the development of authenticity and quality control methods; c) the development of standardization methods for NTFPs. In addition, the aim is to support training at universities and also research on NTFPs. The priority target of the survey were the project partner countries, but potentially interested institutions in other countries have been considered. During the survey, special attention has been paid to the following aspects: a) availability of scale-up facilities and cooperation possibilities of their use; b) barriers and limitations in the research and development infrastructure. Another aim of the survey was to reveal the current capacity of academic institutions and industry, to identify bottlenecks and to support the identification of solutions in order to solve problems.

The analysis on the industry needs in new knowledge, in cooperation with academia, and needs in infrastructure of research was based on the results of the survey as well as the analysis of expert opinions. The survey included 30 questions which were related to the:

- 1) Profile of the enterprise (name, ownership of the enterprise, number of employees etc.),
- 2) Profile of production (main market of products, main profile of production, cultivated berries used in business, wild berries used in business, origin of berries used),
- 3) Profile of berry processing (interests and plans to expand berry cultivation, species interests and plans to expand berry gathering, interests and plans to expand berry processing),
- 4) Knowledge needs profile (sources of existing experience in business, sources of information on NTFPs and their product markets, sources of information on plants used in the production - their nutrition value and other data, knowledge needed to advance in berry cultivation, knowledge needed to advance in berry processing,

quality characterisation, and interest to develop express tests for berry quality- and authenticity characterisation, as well as their processing chain).

The interviews were done using an elaborated Internet tool as well as direct meetings with the enterprises. Altogether 39 answers depicting the situation in the project partner countries were obtained. Interpretation of the survey results the results of previous studies, contacts and discussions with industry representatives in the project partner countries, were considered.

2.1. NTFP processing - profile of businesses

The first level of analysis was related to the profile of the enterprises (name, ownership of enterprise, number of employees etc.) as well as the profile of production (main market of products, main profile of production, cultivated berries used in business, wild berries used in business, and origin of berries used). The aim of the analysis was to evaluate the existing size of the NTFP production in the Baltic Sea Region (BSR), as well as the potential of development. From the perspective of the evaluation related to the capacity of the NTFP industry, the most valuable resources were direct interviews as they provided the possibility to see the infrastructure of the enterprise, get an impression on the intents and motivation, and get an overall feeling on the prospects on the development of the enterprise.

Most of the enterprises analysed during the survey were relatively small with a number of persons employed <10 (Figure 5). The motivations to start the business were related to knowledge obtained during university education as well as considering traditions of the country, and the interviewed persons showed enthusiasm. Thus, it is evident that there are good prospects for the growth of NTFP industry. The “large players” can enter the business, but at the same time, considering the growth potential of the functioning enterprises. However, the survey did not cover large food processing enterprises, such as juice producers, and enterprises where jam and confectionary production are the profile. The processing of NTFPs such as forest berries is a part of side-stream of production. Traditional food processing businesses are working at significantly higher capacity in respect to their size.

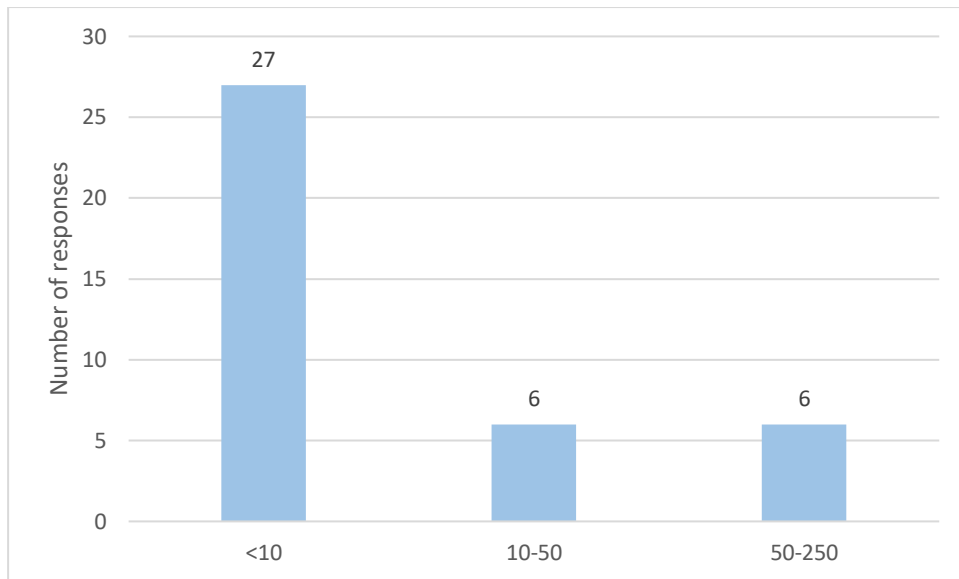


Figure 5. Size (number of the persons employed) of the enterprises involved in the NTFP processing in project partner countries.

The direction of markets of the enterprises involved in the processing of NTFPs can partly be related to the size of the enterprises. The production is mostly covering domestic consumption as well as markets of neighbouring countries (Figure 6). The businesses are mainly located in the bio-product (ecological, natural etc.) market niche. However, except for one businessman (from Norway, working on birch chaga), all the other enterprises contacted have expressed their interest to expand businesses especially in the Asian markets which were considered the most prospective ones.

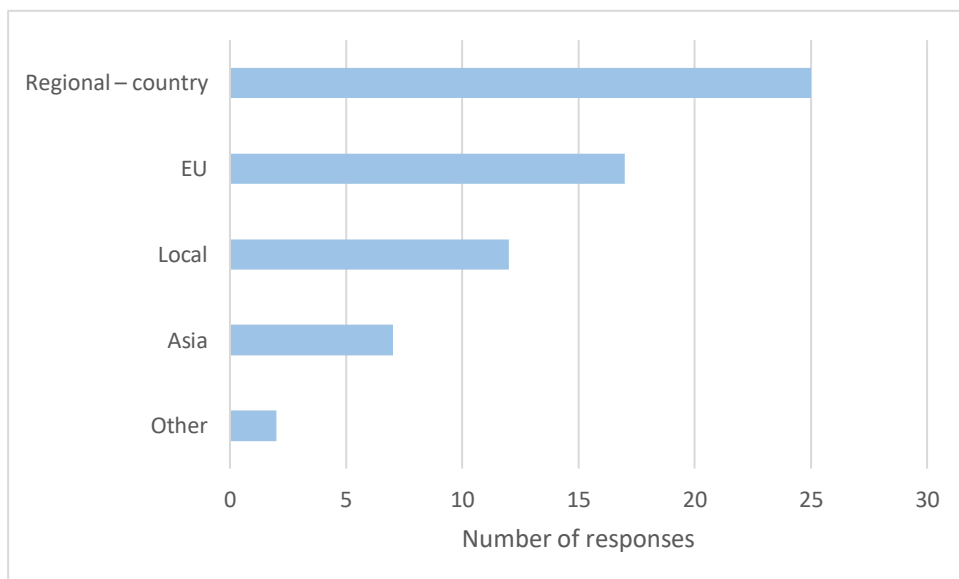


Figure 6. Main markets of the products of the enterprises involved in the processing of NTFPs in project partner countries.

2.2. NTFP business profile in NovelBaltic partner countries

As discussed previously, NTFPs consist of a wide category of products. However, according to the results of the survey, industry mainly focuses on berry cultivation and processing (Figure 7). The other directions of activities include products, such as birch sap, birch and pine bark, bark of other forest trees, pine and spruce, juniper needles and berries. The results of the survey are indicative in respect of the need to study the properties, extraction possibilities and application potential for both food and biopharmaceuticals, as well as cosmetic products. The personal meetings with the enterprise representatives underlined the importance for the development of new applications from NTFPs and the market interests in such products.

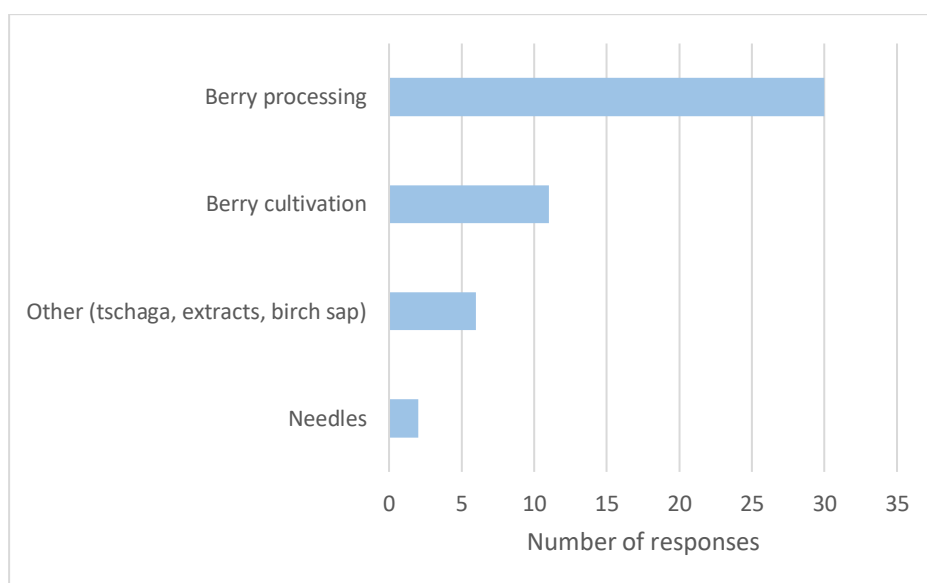


Figure 7. Production profiles of the enterprises involved in NTFP processing in project partner countries.

From the cultivated berries, of highest interest were sea-buckthorn, blackcurrant and raspberries (Figure 8), but from wild berries highly valued are bilberries, lingonberries and cranberries (Figure 9). The cultivated and wild berries were collected either locally or imported from the neighbouring countries, including non-EU countries such as Belarus and Russia (in the case of Baltic States entrepreneurs).

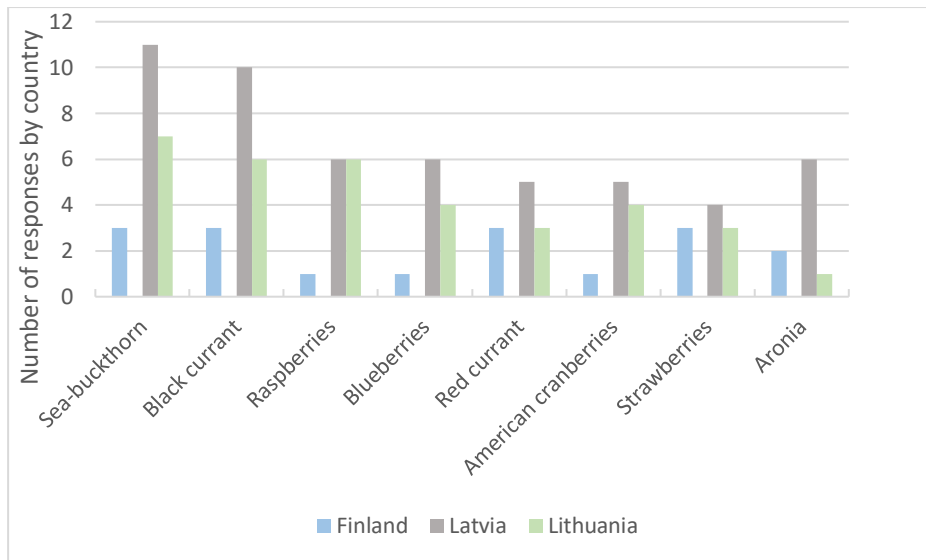


Figure 8. The number of enterprises interested in the processing of cultivated berries in project partner countries.

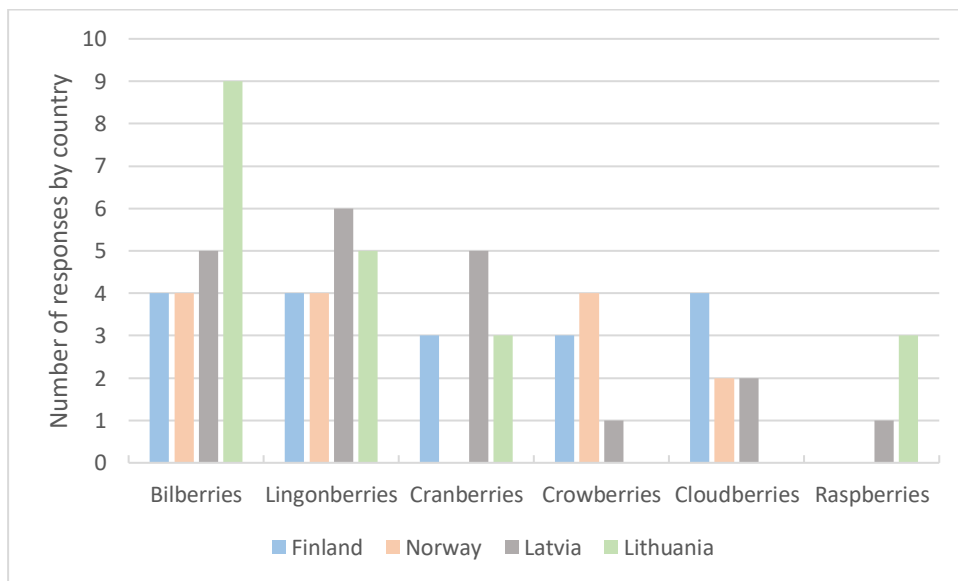


Figure 9. The number of enterprises interested in processing of wild berries in project partner countries.

The most common ways of berry processing in the project partner countries are simple from the technology point of view (Figure 10). Berries are mainly used as fresh, frozen, or dried, and as berry powders, which require only storage or minimal processing. The use of berries for functional foods, food supplements require more processing and are of interest for a relatively small group of enterprises. Moreover, scientific research (molecular analyses, technical outcome, medical applications, etc.) is needed to provide new information on berry properties and their applicability on e.g. berry processing/products for regional and international markets.

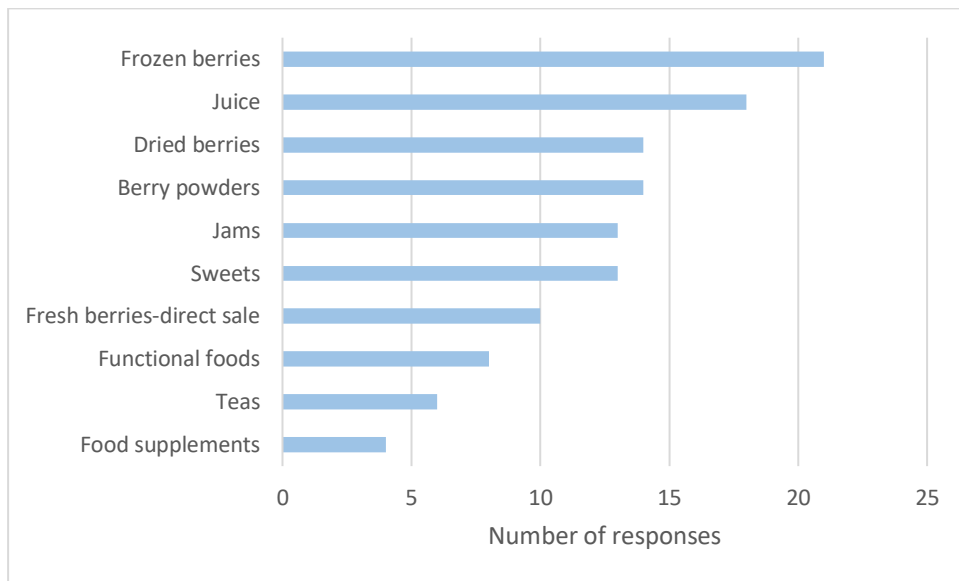


Figure 10. The end products for berries as reported by the interviewed enterprises in project partner countries. The results are based on the number of responses from the enterprises.

The enterprises in the Baltic Sea region are interested in the development of new products as well as their application possibilities and have orientation towards technologically more complex production ways and more advanced berry processing products (Figure 11).

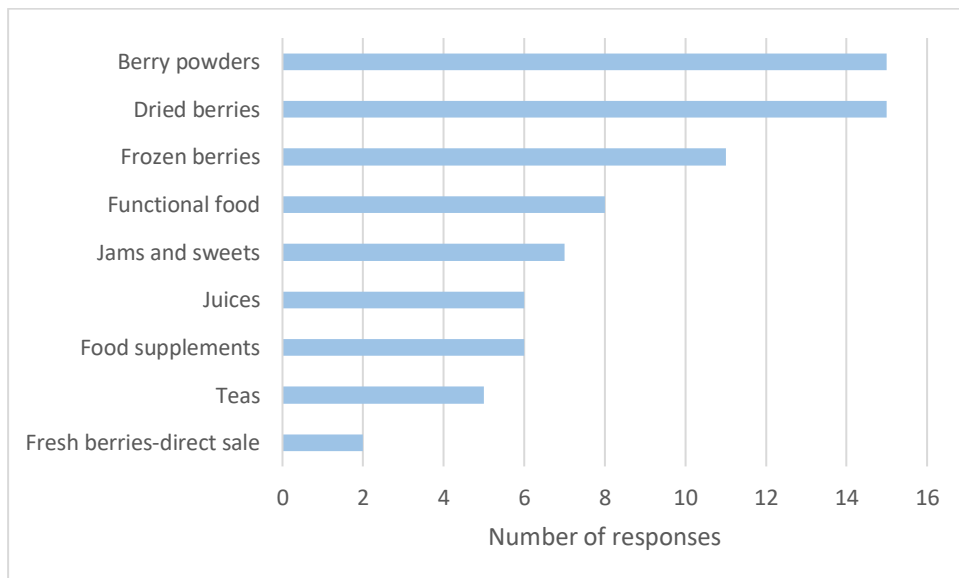


Figure 11. Interest of enterprises in the project partner countries to expand the way of berry processing and development of new products. The results are based on the number of responses from the enterprises.

All the enterprises underlined the need for analytical characterization of NFTPs' quality and composition (Figure 12). During the interviews it was pointed out, that nearly all of the surveyed enterprises have met difficulties to obtain the needed information in full scale accordingly to their needs. The most needed analyses are the ones that provide information

that is important to the consumer - concentrations of vitamins, nutritive value, and macro- and trace elements. Also, the presence of contaminants such as polychlorinated biphenyls, polyaromatic hydrocarbons, radioactivity, etc. was mentioned amongst the parameters critical to prove the quality of NTFPs. However, many producers were interested also for the quantities of functional components in berries, such as the concentration of polyphenolics, the radical scavenging capacity, the concentrations of individual polyphenolics, and lipid content. Correspondingly, the requirements for the regularity of the quality control were quite high (Figure 13). Thus, based on the survey, the need for analytical services can be considered high. However, the costs of the analyses may hinder the companies' interests (Figure 14).

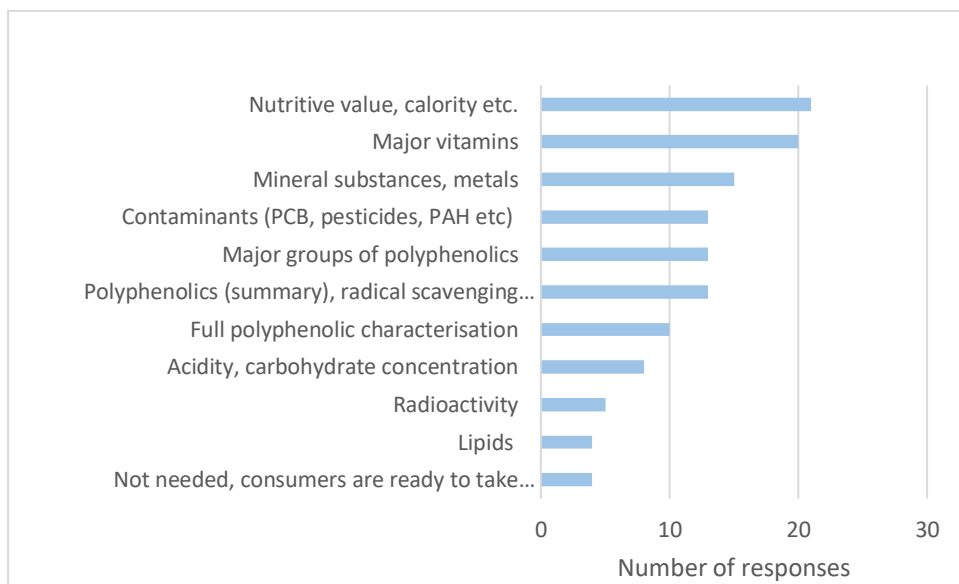


Figure 12. Needs for analytical characterization of NTFPs. The results are based on the number of responses from the enterprises.

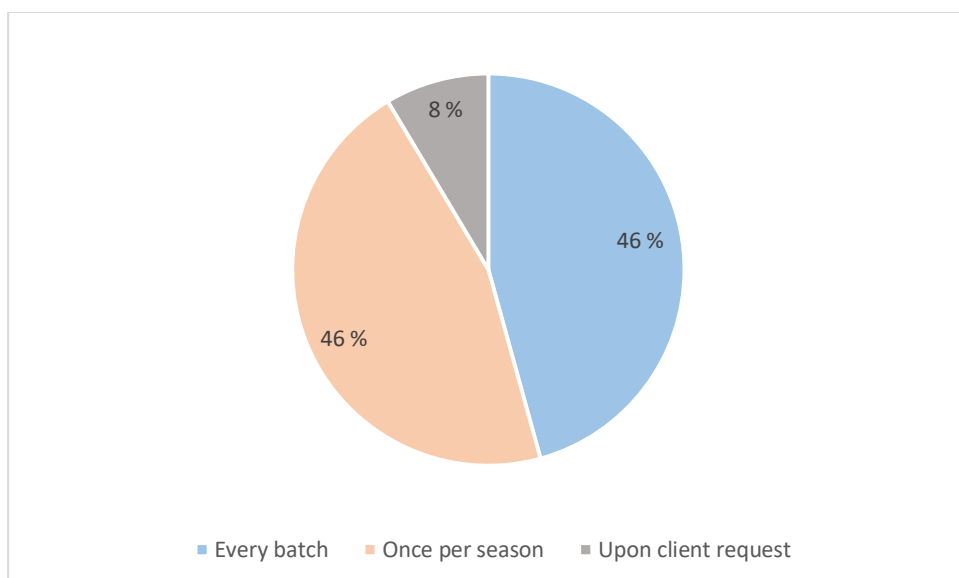


Figure 13. Needs for the regularity of analytical characterization (quality and authenticity) of NTFPs.

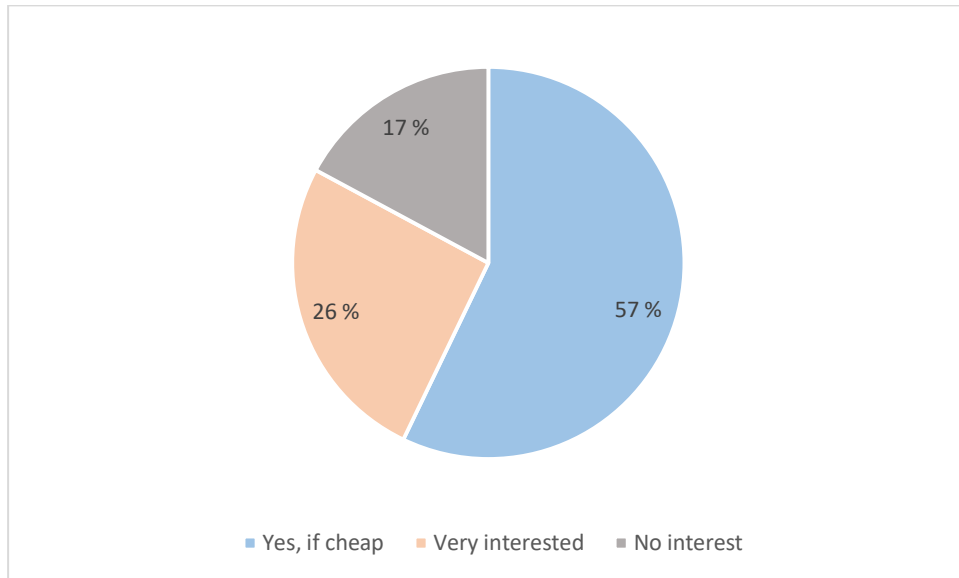


Figure 14. The interest of NTFP enterprises on product quality and authenticity testing.

During the interviews, seminars and informal meetings, the enterprises were informed about the NovelBaltic project and its aims. All representatives of the enterprises expressed their interest to get the information about the project results as well as suggestions on how to improve their business (Figure 15). 76% of the respondents build their experience by consulting with experts in the specific field (universities etc.). 61% get their experience from literature in the specific field. 94% of the respondents gather their information on berries and their product markets on the internet, and only 3% in exhibitions and fairs. 61% of the respondents consult experts in the field and 37% of the respondents share their experience and expertise with professional associations. 81% of the respondents consult experts in field. 75% gather information on the berries used on the Internet and 53% relate to professional literature. 78% of the respondents need knowledge on new markets in order to expand? their berry utilization, while 39% need knowledge for the selection of best species, growth and storage conditions to advance the use and quality of berries and berry products. 85% of the respondents need to improve their knowledge on product development, while 76% need knowledge about the use of new technologies and information about new markets.

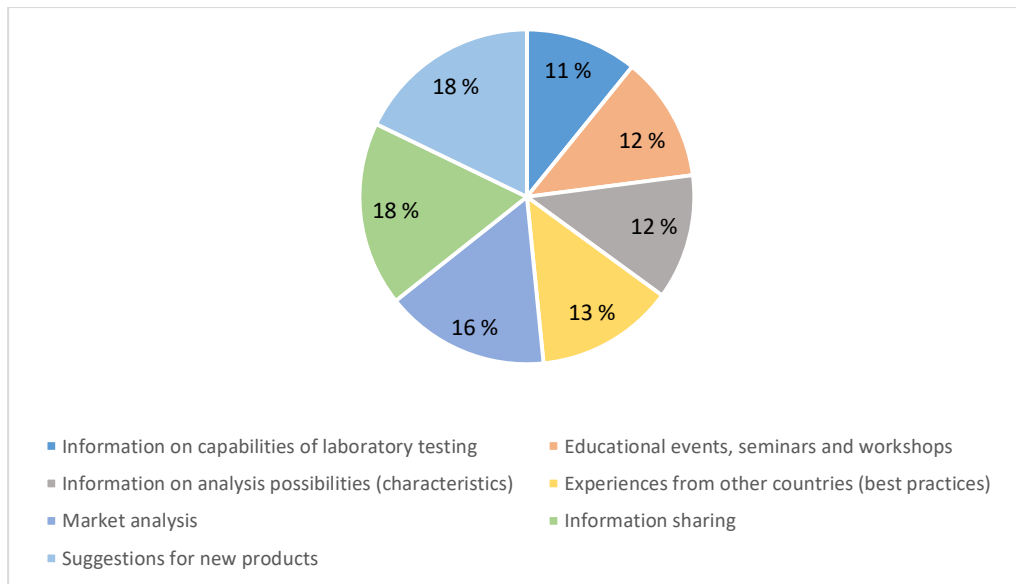


Figure 15. Expectations of NTFP enterprises related to the results of the NovelBaltic project

This result proves the importance of the NovelBaltic project and significance of the obtained results for further growth of the NTFP business and, in a wider sense, of bioeconomy in the Baltic Sea region countries.

3. Research and development infrastructure available to the project partners and NTFP development and characterization

The project partners involved have a wide range of competencies within the fields of NTFP and biomass refinery. Competencies include knowledge on extraction methods used for laboratory scale analysis and pilot-scale experiments, analytical methods for identification of compound groups of interest, and qualitative and quantitative analytical methods used for characterization of specific compounds within a plant extract. For example, the evaluation of extract antioxidative properties can be done within the laboratories of project partners where various methods for determination of radical scavenging potential are used (e.g. DPPH 2,2-diphenyl-1-picrylhydrazyl, ABTS 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), FRAP ferric reducing antioxidant potential, CUPRAC copper reducing antioxidant capacity, and ORAC oxygen radical absorbance capacity). Authenticity testing of products can be done by either the use of analytical chemistry methods (chromatography, stable isotope analysis) as well as DNA-based methods which can be used to find out the sample origin. The methodologies available are presented in Tables 1, 2 and 3.

Table 1. The available extraction methods for NTFP processing in project partners institutions.

Sample preparation and extraction methods	Performed analysis	Material used
Maceration	Comparison of conventional extraction methods and optimization of extraction process based on the used method and used solvents.	Various northern berries (bilberry, lingonberry, American cranberry, blueberry), fruits and their by-products
Freeze drying		
Vacuum ovens		
Ultrasound assisted extraction		
Microwave assisted extraction		
DNA/RNA extraction	Comparison of sample drying methods on degradation of bioactive molecules.	
Supercritical CO ₂ extraction		
Soxhlet extraction		
Volatile oil extraction	To obtain extracts rich with polyphenolics or lipids.	

Table 2. The available chemical characterization methods of NTFPs processing in project partner institutions

Chemical characterization methods	Performed analysis	Material used
Spectrophotometry	Total polyphenolics, anthocyanins, carbohydrates, proanthocyanidins, vitamins, free radical scavenging activity using various methods, enzyme inhibition.	Blueberries, bilberries, bog bilberries, bog cranberries, American cranberries, sea-buckthorn, black currant, raspberries, various exotic fruits and vegetables. Extracts of various berries in powder or liquid form.
Liquid chromatography-MS	Determination of individual anthocyanidins and individual polyphenolics	
Gas Chromatography-MS	Analysis of lipids (fats) and plant wax, volatile substances used in fragrances and flavours, alcoholic beverages, oils	Blueberry varieties, rowanberry, hawthorn berries, crowberries, cranberries, bilberries. Latvian medicinal plants, herbs. Plants used in traditional Chinese medicine.
Titrimetric analysis methods	Total acidity	Berry juices
Stable isotope analysis	Analysis of stable light isotope ratio nitrogen 15, carbon 13, oxygen 18 (for solid samples) and oxygen 18 (for liquid samples)	Algae, mushrooms, honey, apples, grain, dry berries, humic substances
FT-IR	Chemical composition of different material	
AAS and ICP	Analysis of macroelements (Mg, Ca, K, Na etc.) and micro elements (Li, Ba, Cu, Zn, Fe, Mn, Co, Cr etc.) - for samples with low concentration of metals.	Different varieties of blueberries and bilberries to assess their geographical origin. Analysis of metals in honey.
Capillary electrophoresis	Determination of carbohydrates (monosaccharides)	Products containing carbohydrates, birch sap
Fiber analysis	Crude fiber, acid detergent fiber and neutral detergent fiber determinations	Various dried berries, fruits and their processing by-products; dried vegetables and their by-products; dried medicinal, aromatic and spice plants, seeds and nuts
Electronic tongue	Taste measurement and comparison	Fresh fruit, berry and vegetable juice; various fruit and berry products

Table 3. The available cell culture and DNA based methods for NTFP processing in project partner laboratories

Cell culture and DNA based methods	Performed analysis	Used material
Sterile tissue culturing	Cell culturing under sterile cabinets and controlled growth chambers	Bilberry, potato, Scots pine, Norway spruce, aspen, tobacco, birch
High-throughput sequencing	DNA sequencing (e.g. barcoding)	Any species
Microscopy/confocal microscopy/electron microscopy	Analysis of microscopic samples, localization of bacteria and compounds	Any species
Production of transgenic material	Gene transfer and analysis of gene function	Silver birch, hybrid aspen
PCR/qPCR analysis	Isolation of genes and analysis of gene expression	Bilberry, lingonberry, strawberry, blueberry, crowberry, Scots pine, Norway spruce, silver birch, hybrid aspen, etc.

The research institutes and universities from project partner countries have significant experience in NTFP research (both analysis and development of new products) and capacity to work on with new challenges. The infrastructure is able to support new developments and services. The capacity of the infrastructure and resources can already meet the demands of industry, but there is also need to further development in order to meet the expectations of industry and consumers. For most of the institutions surveyed, the weak point is the missing capacity to scale-up with the results of research.