



PROJECT FINAL REPORT

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1. FINAL PUBLISHABLE SUMMARY REPORT

1.1 Executive summary

Bioeconomy and increasingly circular economy direct R&D&I policies and business development within the EU. EU Bioeconomy already has a turnover of nearly 2 trillion € and employees more than 22 million accounting for 9% of the total employment in the EU (ec.europa.eu/research/bioeconomy/). Worldwide bio and increasingly circular economies include, as the core activity, biomass process and product development in the processing industry. The most urgent drivers for this development are, by definition, global climate change, dependency of fossil oil, environmental load from industry, community, agri- and aquaculture, overfishing, livestock production and inefficient exploitation of available and usable biomass, whether virgin or secondary, for proper and profitable end-use purposes.

The APROPOS project was well positioned in the main stream of side stream valorisation. It developed eco-efficient bio-mechanical processing solutions to enrich intermediate fractions from high-quality industrial protein and oil-rich process residues originating from oilseeds and fish. Enzyme-aided mechanical modification techniques were developed to press residue of rapeseed, salmon and Nile perch filleting residue i) to obtain intermediate fractions, with limited but practical purity, and ii) to produce nutritive, technically functional and/or bioactive components to be used in food and skin care. In addition to this, iii) an organic solvent-free extraction process was developed to enrich glucosinolates from mustard seed press residue for crop protection purpose. According to APROPOS philosophy “The Best of the Rest” iv) the efficiency of the remaining low-protein and oil residues in biogas production and soil improvement was investigated. Selected processes were evaluated in terms of techno-economics and environmental effects.

APROPOS co-streams, i.e. fish filleting residues and rapeseed and/or mustard press cake, are voluminous food-grade industrial streams in Europe and globally. Wasteless biorefinery solutions under development aimed at avoidance of unnecessary over-purification of the components, establishment possibilities of local and distributed processing units in connection with the primary production and new business opportunities essentially for SMEs in Europe and beyond. An emphasis was directed also to East Africa and India to support their needs to process local residues to products to nourish people living on low-protein diet (95 % of the population in e.g. Uganda and Kenya) and fight against pests in agricultural areas (India). The success of the technological developments was assessed in terms of techno-economic feasibility, analysing new value chain creation, raw material efficiency and environmental impacts.

Essentially the entire value chain/network from crop production and aquaculture to companies producing food and food ingredients, bioactive components for human consumption and crop protection, as well as those enterprises capable and willing to treat the ultimate residue/waste to either energy or chemicals should react to the disquieting future of uncontrollably increasing population, over use of renewable natural resources and shortage of nutritious food.

1.2 A summary description of project context and objectives

APROPOS Concept

“More value – less waste” philosophy directs strongly the research and innovation policies of the European Union, as well as process and product development of the biomass processing industry worldwide. Among the most urgent drivers are the global climate change due to greenhouse gas emissions, dependency of fossil oil, environmental load from industry, community, agri- and aquaculture, livestock and animal production and inefficient exploitation of usable biomasses for fair end-use. There is an urge to find ways to exploit waste and co-streams produced by the above mentioned sectors in an eco-efficient manner. The term “Biorefinery” means the co-production of a spectrum of bio-based products (food, feed, materials, and chemicals) and energy from biomass [definition IEA Bioenergy Task 42].

The APROPOS project, addressed the topic “*KBBE.2011.3.4-01 BioWaste – Novel biotechnological approaches for transforming industrial and/or municipal waste into bioproducts*” by focusing on developing a wasteless biorefinery concept to valorise two different industrial co-streams containing high amount of protein and oil. The APROPOS biorefinery concept aimed at complete exploitation of the mentioned high protein and high oil containing industrial co-streams (fish filleting residue and rapeseed press cake) by environmentally benign biomechanical processing technologies to produce intermediate fractions and value components for food and skin care products and exploit the remaining residue for bioenergy, soil improvement and crop protection. The high quality demands of APROPOS end-use applications prohibited the possibility to use non-food quality waste as raw material. Therefore rapeseed and fish filleting co-streams, which have high enough quality for food use, were excellent choices as raw materials. APROPOS wasteless biorefinery:

1. allowed concurrent enrichment of multiple valuable components
2. avoided unnecessary over-fractionation or purification
3. allowed establishment of local processing units in connection with the primary production
4. allowed new business opportunities particularly for SMEs due to simple processing solutions

APROPOS enriched high-value intermediates from industrial co-streams, rapeseed press cake and fish filleting residue, by environmentally benign processing technologies, which combined mechanical and enzymatic process steps (*Figure 1*). APROPOS replaced harsh chemicals with enzymes and focused on reduction of excess water and organic solvent usage. The developed processes avoided harsh process stages which may cause changes in the protein functionality and oxidation of the lipid components. The chosen co-streams are suitable for the production of value-added food and cosmetic components. Therefore in APROPOS these components were up-graded to be appropriate for value-added end-uses, such as food, cosmetic and medicinal skin care products.

APROPOS increased the raw material efficiency and sustainability of the existing industry and provides building blocks for the creation of new co-stream processing industries, by creating bio- and mechanical processing concepts to up-grade the co-streams into high-value bioproducts without disturbing the current bulk use of the co-streams for lower-value feed or energy. This broadens, by definition, the scope of the business opportunities for the existing fish processing enterprises and rapeseed oil pressers, but also offers opportunities to create new industry aiming at developing high-value products from industrial co-streams or waste. Simple changes in the existing processing were required to convert the present processing of the selected co-streams to an APROPOS biorefinery, i.e. 1) replacing chemicals completely or partially currently to enzymes, 2) adding an enzyme treatment step to existing mechanical processing or 3) replacing organic solvents to water. APROPOS focused on the following development paths:

1. Development of wasteless concepts exploiting enzymes to up-grade rapeseed press cake and fish filleting residue by enriching proteins, lipids, phospholipids and glucosinolates as intermediate fractions and exploiting the remaining residues in bioenergy and soil improvement.
2. Applying enzymes to up-grade the intermediate products to be utilised as functional ingredients or additives in foods and cosmetic/pharma products.

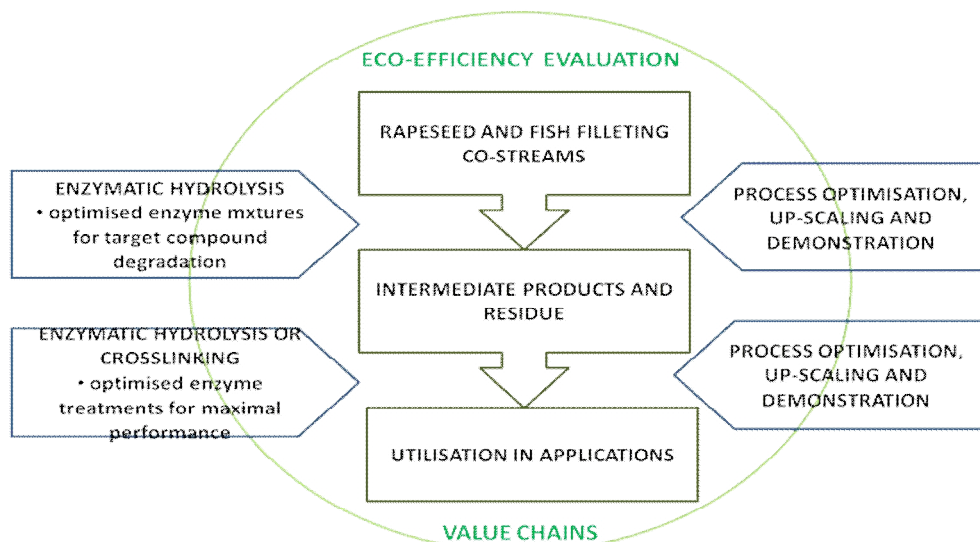


Figure 1 The approach of APROPOS.

The APROPOS ideology lay on the crosswise exploitation of the knowledge on processing and up-grading developed independently in the agricultural sector (rapeseed/mustard) and fishery sector. Although the two selected co-streams differ from each other, both of them contain high concentration of protein, oil, bioactive components and minerals and they provide a valuable biomass source of nutritional components to be added to low-nutrient diets in developing countries and multitude of value-added components for food and skin care formulations such as:

- antioxidants for food preserving and wound healing
- protein with high nutritional quality
- protein hydrolysates with good digestibility, bioactivity and technological performance for nutrition and skincare
- polyunsaturated fatty acids, phospholipids, and lipid soluble antioxidants and vitamins for nutrition
- minerals such as phosphorus for soil improvement
- glucosinolates for pesticides to be used in crop protection.

Up-grading concepts under development were or included the following:

- maximization of efficient used of the chosen co-streams
- generation of increased economic value, ethically viable uses of the biomass resources and environmental benefits
- enabling establishment of small, regionally distributed processing units
- creation of business opportunities specially for the SME sector both in Europe and ICPC countries
- networking stakeholders from producers and processors as well as from the co-streams to their end-users to perceive functional and whole value chains
- building bridges between industrial actors processing agriculture and aquaculture derived raw materials.
- building bridges between experts in Europe, North America, East Africa and India.

APROPOS objectives

The main objective of APROPOS was:

To develop *techno-economically feasible and sustainable* zero waste processes based on benign, organic solvent-free fractionation technologies to exploit fish filleting residue and rapeseed press cake as raw materials to ingredients and additives for food and skin care formulations as well as chemicals for soil improvement, crop protection and energy.

The main objective was accomplished through the following sub-objectives with measurable success factors (success factors not shown):

1. To develop a process that is easily adapted by local SME's also in developing countries for the up-grading of the co-streams at the site of their production in order to ensure the sustainability of the processing technologies by preventing costs and CO₂ emissions caused by the unnecessary transportation.
2. To develop benign processing technologies to enrich intermediate products (protein, protein-oil, peptides, lipids, secondary metabolites) from fish filleting residue and rapeseed press cake by primary fractionation, enzymatic treatments, organic solvent-free extraction stages and by their innovative combinations.
3. To develop downstream, up-grading and stabilising technologies for intermediate products (protein, protein-oil, peptides, lipids, secondary metabolites) to produce

biomaterials, nutrients, bioactives and value-added chemicals with high chemical and microbiological quality and stability for human use.

4. To upgrade the intermediate products to be used as alternatives for existing soy and animal proteins in foods and skin care applications, to be used as natural antioxidants in oil products and as components in biopesticides.
5. To demonstrate technical feasibility of the most promising processing technologies and end-use applications developed in pilot or mill scale.
6. To assess the techno-economic feasibility and sustainability of the developed process concepts and to create functional value chain around the novel concepts.

1.3 A description of the main S&T results/foregrounds

1.3.1 Overview of the project outcome

APROPOS project fulfilled its objectives mostly as was described in the original work plan, all the deliverables were realised and milestones reached as promised. Collaboration within the consortium throughout the project was 'high spirited', active and fluent and five project meetings and a final meeting in connection with the APROPOS coordinated "The Best of The Rest" symposium together with three European projects going on in the field of co-stream valorisation and minimal processing were successfully organised.

Selected raw materials and intermediate fractions were sent throughout the project to appropriate partners for further treatments and analyses. Samples were characterised to practical extent avoiding dispensable over-characterisation in terms of chemical composition and structure, chemical and microbiological quality. Sample sending logistics and building and implementing the complementary 'analysis service' among partners functioned fluently and efficiently.

In processing of co-streams to intermediates focused on developing technologies for enrichment of the chosen intermediates (proteins from fish filleting residue and rapeseed press cake; de-hulling of rapeseeds and mustard seeds; extracting glucosinolates from mustard press cake and various lipids from fish residue) and optimisation of the said processes what comes to raw material, process chemical usage and water consumption. An important aspect was to obtain scientific and technological understanding about the behaviour as well as chemical and structural changes when the raw material was converted to intermediates in the processes under development.

Intermediates were investigated as such in certain food applications and further processed to value components for food and skincare use. This work concentrated on selecting best working enzymes for protein hydrolysis followed by optimisation of the enzyme-aided hydrolysis of fish and rapeseed proteins. The peptide mixtures were analysed for bioactivity and stabilisation method was established. The final protocol to extract glucosinolates from mustard press cake without organic solvent developed.

Waste-free solutions have been the general goal of APROPOS. To reach this goal, low-value residues of the co-streams processed to intermediates were further processed to energy and/or fertilisers. Fish bones turned out to be an inconsiderable component in biogas production. In soil improvement studies, fish bones increased available phosphorus and mineral nitrogen content in the studied test soils. The ultimate rapeseed processing residues (low in oil and protein) had positive effect on the concentrations of certain minerals in the soil. The rapeseed press cake residue was found to significantly increase the microbiota abundance in the soil.

Three development cases were demonstrated in pilot scale or as product prototypes: I) Enrichment of protein, protein hydrolysates and oil for food supplements for African use (European – African academia/SME collaboration), II) Building an equipment for pilot scale extraction of glucosinolates from mustard seed press cake and up-scaling the glucosinolate process (Indian-European academia/SME collaboration), III) Production of peptides from rapeseed and fish proteins, embedding the peptides in carriers and testing the bioactivity efficacy and stability of the peptide containing particles in daily and medicinal skin care prototypes (Catalan-Finnish-Norwegian-Canadian academia/SME collaboration).

1.3.2 Progress in the individual work packages

WP1 Co-streams from fish fillet and rape seed processing for common technological utilisation

Objectives:

- To evaluate and characterize selected co-streams from fish filleting and rapeseed processing to be used as raw materials for the production of value added products (main)
- To select, sample and distribute the raw materials to the partners
- To characterize physical, chemical and microbiological properties of the raw materials and intermediate fractions
- To ensure chemical and microbiological quality of the raw materials and final products

Progress:

WP 1 performed practical chemical and microbiological characterization of the raw materials of APROPOS, i.e. salmon and Nile perch filleting residue and organic solvent-free press cake of rapeseed and pressing residue of Indian mustard. The WP also focused on performing well-targeted characterisation of intermediate fractions processed from the raw materials. This WP was responsible for the delivery of characterized raw materials and intermediate products to partners working in different WPs throughout the project. Basic

chemical composition and microbiological quality as well as chemical and microbiological stability of the raw materials and intermediate products were evaluated to ensure the quality of the final products. In addition the logistics of the sample flow among partners was taken care in WP1. A detailed sample table was created and maintained in the WP to track every single sample produced and treated in the project. A survey about the industrial production of rapeseed and mustard oils as well as fish fillets was written and delivered. The survey contains information about production volumes, production processes, areal differences, varieties and species, price development, end uses, markets and political aspects and their influence on the raw material production. Another survey was written about chemical and microbiological factors affecting stability of biomaterials i.e. rapeseeds and mustard as well as fish and fish processing residues during storage and transportation. In the review also critical points and measures to prevent quality loss along the processing chain were surveyed.

Amount of fish residue generated in the fishing industry in Norway is more than 800 000 tons per year. Only from the aquaculture industry 275 000 tons rest raw materials are produced. The significant part of the rest raw material in Norway is utilized: up till 76% of total volume, but the majority of the by-products was used for production of animal and fish feed, either by preservation with formic acid (silage, 40 % of utilised rest raw materials, further processed to oil and proteins) or as fish meal (27 % of utilised rest raw materials).

In Kenya Lake Victoria supports vibrant fish export industry and it is one of the major foreign exchange earner of partner states sharing the Lake (Kenya, Uganda and Tanzania). It is dominated by four main fish species; Nile perch and Nile tilapia, dagaa and haplochromines. Average annual fish catch is estimated at 2.1 million tons with Nile perch, dagaa, Tilapia and haplochromines contributing clearly less. Nile perch is the main species processed for export by the three countries and contributes 60% of the beach value with 35 processing factories located along the Lake. Over 80% of the total Nile perch fish and fish products are exported to abroad/overseas markets. By-products from Nile perch processing constitutes 48% of the whole fish: 35.9% frames (head, skeleton, fins), 3% trimmings, 0.1% roe , 6.1% skin, 1.8% fat pads, 0.3% factory rejects and viscera.

The EU and national legislation with focus on biodiesel application pushed rapeseed (mainly *Brassica napus*) cultivation, especially in Germany (1.400.000 ha in 2011), but not in Finland. In 2005 ten centralized oil mills, located at the big rivers like Rhine, Elbe and Weser realized the oil pressing of 5.5 million tons rapeseed to 2.2 million tons of rapeseed oil. The processing capacity is between 1.000 tons and 4.000 tons/day. 65% of produced rape seed oil is used for fuel. In Finland most of the oil is used for food. There is one large and four SME oil mills. In total they are processing about 100.000 tons/a of rapeseed (mainly *Brassica rapa*).

Press cake of rapeseed became with growing value of biodiesel production an important component in animal feed. The price is strongly influenced by the international price structure for soy cake. SME oil mills in Germany or Finland do not use hexane extraction, but only cold or warm pressing of seeds. Two of mills in Germany use de-hulling process

before pressing to get better quality oils for food markets. Their press cakes are particularly good raw materials for innovative protein products. Till 2014 rape seed protein isolates were accepted for food in US and Canada (GRAS status), but they are “novel food” in EU. In summer 2014 EFSA opened the way for rapeseed protein isolates into European food market. This fact and changes in biodiesel regulations in EU after 2020 (only used oils will be accepted) will change the philosophy of oil mills. Press cake and especially the proteins from rape seed will become a much higher position in price building. So the results of APROPOS in protein processing meet the needs of policy and industry.

For mustard processing in India the FAO-stat does not deliver any figures. World production is about 0.5 million tons (2012). The searches from Indian project partners express, that India has an annual mustard seed production of about 7.5 million tons (2012) - 15 times more than official world production! Mustard seed (*B. nigra* and *B. juncea*) are the most important sources for food oil in north of India. Processing is realized in many very small enterprises. Press cake is used as feed. Project partner TERI analyzed the different varieties (*Brassica napus*, *Brassica rapa* from EU and Indian *Brassica*) seeds and samples/fractions from processing steps. *Brassica juncea* and *Brassica nigra* are valuable sources of glucosinolates. After contact with water the enzyme myrosinase splits glucosinolates to isothiocyanates, glucose and sulfuric acid. TERI detected the different types of isothiocyanates in the different varieties and fractions. Hulls do not contain glucosinolates. Isothiocyanates are an essential component in Indian food oil (hot taste), remaining isothiocyanates could become an environmental friendly component in green house and ground sanitation. The composition of fatty acids of the Indian oil from *Brassica juncea* and *Brassica nigra* have contents of erucic acid up to 50 % and more. In EU since 1977 the content of erucic acid in food oil is limited to 5 % only. Characterization of the sample compositions was an essential factor to select and determinate useful steps in the process development.

WP2 Processing of co-streams to intermediate products

Objectives:

- To develop and optimize zero-waste organic solvent-free fractionation technologies of the raw materials to obtain intermediate products (protein, oil, antioxidativity and glucosinates) in high yields (main)
- To develop primary fractionation methods to enrich protein, oil and antioxidativity from rapeseed meal and hulls and glucosinolates from mustard seeds
- To select carbohydrate degrading enzymes and treatment conditions for targeted cell wall disassembly to facilitate and maximise the enrichment of intermediate products from rapeseed meal, rapeseed hulls and mustard
- To select protein treatment conditions and degrading enzymes and to separate protein and oil from fish filleting residue in high yields

- To combine enzyme treatment steps to mechanical processing technologies for enrichment of intermediate products
- To determine critical process parameters affecting the quality of the intermediate products and to deliver characterized samples to WP 3 and WP 4
- To evaluate options for eco-efficient exploitation for the remaining fish bones and protein/oil depleted rapeseed residue

Progress:

In WP 2 technologies for processing of co-streams, i.e. rapeseed, mustard, salmon and Nile perch residues to intermediates have been developed. In addition to straight forward technology development, scientifically oriented research work has been carried out, when necessary, to understand better the chemistry and structure of the residue raw materials and how do they behave during processing.

In order to develop and optimise primary fractionation methods to rape seeds and rapeseed press cake technological trials were performed in lab and industrial scale. It was found that cryogenic milling is a good way to reach a small particle size (thus facilitate extraction of protein) without de-fatting the press cake. Press cake was also de-fatted with supercritical CO₂ extraction, milled and air-classified in order to separate hull fraction and facilitate protein extraction from the kernel-rich fraction. Supercritical CO₂ extraction was efficient, although costly, in defatting method, but its use was justified as it is a non-organic solvent alternative to hexane. This WP focused also on transferring the established dehulling, separation and pressing technologies of rapeseed on mustard seed. For the pressing procedure same equipment was used like with rapeseed. The trials proved the ability of the existing technology to be used for mustard seed.

The gas assisted pressing was tested to remove oil from rapeseed. Tests proved the possibility of advanced results on cold pressing compared to conventional methods. In case of pressing with higher temperatures this method showed less effective results. Upscaling of the technology proved that process is repeatable but during pressing in cold the press cake still contains oil.

Enzymatic hydrolysis of cell wall and other carbohydrates was used as a means to facilitate protein recovery from rapeseed press cake. Based on the carbohydrate composition of the cold-pressed rapeseed press cake, commercial enzyme preparations containing cellulases, xylanase and polygalacturonase (pectinase) activities were selected and compared. An enzyme product having polygalacturonase as the main activity was found to be the most effective in carbohydrate hydrolysis and liberating protein from the press cake. Primary fractionation by dehulling, cryo milling, coarse and fine milling, SC-CO₂ extraction and air-classification all enhanced the extractability of proteins. The most effective combination, dehulling followed by cryo milling, enabled good protein recovery even without an enzymatic treatment which, however, improved the protein release from the less processed press cakes. Protein was also extracted from the press cake at reduced water content from defatted and non-defatted rapeseed press cake and characterized for selected

physiochemical properties. The aim was to reduce the overall water consumption of the process and by extracting the proteins without pH adjustment, prevent the introduction of salts into the protein concentrates. Alkaline extraction in dilute conditions (commercial processes) was used as the reference procedure. De-fatting of the press cake by SC-CO₂ extraction facilitated protein recovery at reduced water content. Enzymatic hydrolysis of carbohydrates was feasible at high consistency, but effective protein extraction from the enzymatically treated press cake required dilute conditions. After treating the press cake with a pectinolytic enzyme product, comparable amount of protein was extractable without the need for alkali or salt addition, as using non-enzymatic alkaline extraction. The obtained protein concentrates contained up to 83% protein. Physiochemical properties of the protein concentrates were affected by the presence of non-protein compounds such as pectic carbohydrates and uronic acids, sugars and lipids: most importantly, protein-sugar concentrates from aqueous (pH 6) extraction showed better solubility and dispersion stability than traditional isoelectric protein precipitates from alkaline extraction and acidic precipitation.

Glucosinolates are sulphur and nitrogen containing plant metabolites common in the genus *Brassicaceae* (rapeseed, mustard). Plants which synthesize glucosinolates possess an enzyme called myrosinase, which catalyzes the hydrolysis of glucosinolates to compounds with various biological activities some of which can be antinutritive or even toxic to mammals. Nevertheless, glucosinolates and their hydrolysis products belong to a plant's defense system against insects, and certain microbial pathogens. Glucosinolates are in low amounts in bred rapeseeds and canola cultivated in the West, but in Indian mustard species the amounts are significant. Therefore, in APROPOS an equipment and organic solvent-free enrichment method was developed to mustard press cake as a collaboration of a research institute and processing/machinery manufacturing company to recover glucosinolates to be used in biopesticides but also to facilitate protein enrichment for food or feed use. Extraction methods to enrich glucosinolates from several de-fatted mustard and rapeseed cakes were tested and evaluated. The purpose was to get a glucosinolate concentrate for biopesticide use having sufficient antifeedance efficacy against the grotty and massed insect oriental leafworm moth (*Spodoptera litura*). Mustard and rapeseed varieties grown in India have high glucosinolate concentrations compared to European or Canadian varieties. It was found that brown toria variety contained very high amount of glucosinolate. Methanol is presently used as extraction solvent as it deactivates the myrosinase enzyme which activates by water. Myrosinase converts glucosinolates to isothiocyanates. Therefore, a water extraction method was developed in order to get rid of the organic solvent. Extraction temperature was found to be crucial for the extraction efficiency. The formulations obtained with water extract were very stable.

Initial quality and composition of fish residues are critical for following technological operations and quality of the final products. A commercial bioluminescence detection kit was found to be a convenient test system to detect proteolytic activity in various salmon co-streams. Fast and advanced NMR technique was used as a tool for identification of quality changes and release of bioactive components from fish residues. Salmon filleting residues contain high amount of lipids and due to this it oil was separated before the protein

hydrolysis by elevated temperature treatment. Separation gave high quality oil and at the same time it reduced the amount of raw material sent for hydrolysis. Commercial proteases of different specificities were investigated in facilitating protein and oil liberation from thermally de-fatted salmon residues. The best enzyme to give the highest protein yields produces also the least bitter hydrolysates compared to the other studied enzymes. A new two-stage thermal-enzymatic technological solution for residual oil and protein extraction technology developed to from salmon residue was found in techno-economic evaluation to give both economical and quality profit. In this developed technology during the first stage oil is separated after light heating and in the second stage remaining oil and proteins are separated by enzymatic treatment. This solution led to more efficient hydrolysis process and lower enzymes cost, which was verified in lab and pilot scales. This technology will be up-scaled to commercial scale.

Residues of Nile perch (*Lates niloticus*) were treated similarly and hydrolysed with commercial protease products. The main focus was directed to process optimization to increase protein/hydrolysate yield as well as to obtain high quality and acceptable sensory properties of both oil and protein fractions. Best yields were achieved in a simplified system, in which enzymatic hydrolysis was performed without water addition or pH adjustment.

Up-grading of fish residue processing equipment from non-food quality to food quality was carried to the point where up-grading plans were ready and evaluated on a conceptual level. Realisation of the actual hardware and other equipment could not be realised in the project due to high investment costs which were not included in the project budget. It was found that one phase separation is not enough in order to remove water and solids from the oil. Higher temperature than 85°C was found to be advisable in the oil separation process. Grinding and several hours heat treatment were found to be prerequisites to separate protein from fish filleting residues. If the main product is fish oil, the centrifugal decanter can be replaced by a revolving filter and thus save energy, investment cost and more easily handle the fish mass. However, when the main product is protein mass, mechanical pressing separation is needed in order to achieve certain level of dryness before drying process. Formic acid can be replaced by other antioxidants and acids if the by-products are not processed to food supplement. Upgraded prototype of the food-grade process equipment for fish filleting residue was designed. Raw material hygiene and maintaining clean condition of processing equipment are prerequisites for food supplement production. High dryness in solids separation process saves heat energy in drying.

Samples of mixtures of fish bones after hydrolysis (BH) and fish backbones (BB) with cow manure were anaerobically digested to produce energy and fertilisers. As expected, fish backbones were found to be clearly better component in digestion than bones after hydrolysis of protein. Anaerobic digestion of the low protein and oil residue of rapeseed press cake after pectinase and protease treatments were performed during batch experiment on laboratory digesters. Anaerobic biological degradation of samples was found to be very intensive. Two soils differing in pH value and in the texture have been taken for the experiment settlement in order to identify any changes of soil characteristics and soil microbiota. The results obtained show that fish bones processing co-streams

application in all cases has significantly influenced the increase of available phosphorus and mineral nitrogen content. The application of digestate from the mixture of fish bones and cow manure has significant impact on the potassium content increase in the tested soils. An application of digestate have had significantly decreased the acidity of loamy sand soil and increased content of organic carbon content in sandy loam soil. The positive effect also estimated on the content of calcium, magnesium and sulphur in the tested soils. Fish bones application has also significantly influenced the increase in microbiota abundance in sandy loam (agricultural) as well as in loamy sand (forest) soils.

The rapeseed processing residues application has significantly influenced the increase in organic carbon, mineral nitrogen, available phosphorus and available potassium concentrations in the tested soil. In general, the rapeseed processing residue had positive effect on the concentrations of calcium, magnesium and available sulphur and microbiota abundance in the tested soils.

WP3 Up-grading intermediate products for end use applications

Objectives:

- To develop up-grading and stabilising technologies for intermediate products obtained from WP2 and study the application potential of the intermediate products and further up-graded value-added components in foods and skin care applications (main)
- To evaluate the application potential of antioxidant phenolic concentrate of rapeseed
- To evaluate the efficiency of mustard glucosinolates as biopesticides
- To recover and concentrate health beneficial lipids
- To develop a method to liberate bioactive peptides from rapeseed and fish proteins by targeted enzymatic hydrolysis and evaluate the efficacy and safety of the liberated peptides
- To evaluate stability and functionality of the intermediate products targeted for food applications to alleviate malnutrition of African children and to replace animal and/or soy protein in model foods
- To upgrade protein, antioxidant containing intermediate products and bioactive peptide hydrolysates into biomaterials to be used as plant- or fish-based alternatives for existing animal protein-based matrix materials in medical and cosmetic skin care

Progress:

Development of techniques for further processing of intermediates from rapeseed, mustard and fish residues and characterisation of the fine-tuned added value components obtained after valorisation were carried out. Development of intermediate processing methods were targeted to i) controlled enzyme-aided hydrolysis of proteins to obtain bioactive peptides, ii) insect antifeedancy testing of extracted glucosinolates, iii) recovery of valuable lipids and enzyme-aided liberation of PUFAs, iv) evaluation of the functionality of the value fractions in food and skincare applications.

Salmon and rapeseed protein-enriched fractions were treated enzymatically to hydrolyse the protein to short peptides a set of bioactivities as a target. The liberation of bioactive peptides from salmon and rapeseed press cake was performed using state-of-the-art knowledge of enzymatic hydrolysis of proteins. Proteolytic enzymes with different specificities were used as such and in combinations to obtain a desired hydrolysis degree.

Bioactivity of peptide mixtures was investigated what comes to efficacy and safety in preclinical cell systems and biochemically. Glucose transport, antioxidativity, anti-inflammatory, bacteriostatic and antimicrobial efficiency were the main bioactivities investigated. Part of these analyses was carried out as a PhD student collaboration of VTT, SINTEF, UPC and University of Manitoba (Canada). The results showed that iron chelating ability of salmon peptides slightly decreased with the duration of hydrolysis. Antioxidativity results obtained were contradictory. The larger the peptides the better ability they had to chelate iron, explaining the deterioration of this property with the increase of hydrolysis time. Opposite behaviour was observed in terms of DPPH scavenging activity. Promising ACE-inhibiting effect in vitro was obtained from all studied salmon samples. The ACE-inhibiting and glucose uptake-inhibiting activities depended on commercial enzyme used and time of hydrolysis.

To obtain bioactive peptides from rapeseed proteins, the protocol designed to hydrolyse the salmon proteins was applied with some modifications. Most of the rapeseed peptide mixture samples showed an increased radical scavenging activity which was well in line with the phenolic content of the samples. The DPPH radical scavenging activity was shown to be directly proportional to the sinapic acid content of the samples. The hull fractions showed the lowest antioxidant activity, while the kernel-rich samples appeared to be the best antioxidants. The yield of peptides and amino acids was consistent with DPPH radical scavenging activity of the hydrolysates. Treatments with combined endo- and exo-peptidases produced desirable results in the case of endoprotease combinations, whereas exopeptidases did not give additional benefit to the endoprotease treatments. Intestinal enzymes were shown to further hydrolyse rapeseed peptides into smaller di- and tripeptides.

The most bioactive peptide samples were defined for further product development. samples were characterised in terms of protein content, phenol content (in case of rapeseed peptide hydrolysates), antimicrobial activity, antioxidant activity, antiwrinkle/inflammatory properties and biocompatibility (cell viability). The hydrolysis process was shown to increase the antioxidant activity of rapeseed samples indicating that also peptides had antioxidant property. The anti-inflammatory activity of the rapeseed hydrolysates could be related to both phenol and peptide content. Rapeseed samples were more efficient against the Gram-positive *Staphylococcus aureus* while salmon hydrolysates were more efficient against the Gram-negative *Escherichia coli*, though the rapeseed samples induced much less bacteriostatic activity. Finally, the biocompatibility studies indicated that the samples were harmless to skin in concentrations lower than 10 mg/ml.

The peptide samples originating from both rapeseed and salmon were selected according to their combined bioactivities and further up-graded into cosmetic and medical skin care formulations. The peptide samples were embedded to sonochemically produced nanoparticle carriers to increase the stability and bioactive performance.

An analytical method using Rancimat equipment (analysis system for determination of the oxidation stability of natural fats and oils) was developed to be used as an alternative to the DPPH radical scavenging assay for measuring the antioxidant activity of the project samples. It turned out that DPPH radical scavenging activity seemed to measure also the hydrolysis degree of the protein rather than clearly only the antioxidant activity. The Rancimat data and their comparison gave an overview about the antioxidative stability of the selected rapeseed protein hydrolysate samples.

ES expected, need for crop protection is vast in agricultural areas of India. Bio-based anti-feeding pesticide originating from a sidestream of an edible plant is sustainable and environmentally benign solutions at its best. The evaluation of the efficiency of crude, fractions and methanol and water-extracted mustard glucosinolates to act as biopesticides was assessed against *Spodoptera litura* larvae. Several extracts were tested with this bio-assay and the mustard seed extracts in concentration 100 mg/ml showed very high anti-feedancy activity against *Spodoptera litura* larvae, almost equivalent to the standard sinigrin (10 mg/ml). It was successfully proved that extracted glucosinolate samples exhibit antifeedancy and growth inhibition properties against *Spodoptera litura* insect.

The isolation and concentration of phospholipids (PL) from salmon residue and 'normal' triglycerides from Nile perch residue were carried out. Characterisation and antioxidant analysis of PUFAs isolated from Nile perch and salmon oils were performed. Commercial proteases were used to facilitate the extraction of. Maximum oil yield was obtained when hydrolysis was performed with Protex 30L at 55 °C, without pH adjustment or water addition. It was found that enzyme-assisted oil recovery of oils was almost as high that obtained using solvent extraction. Enrichment of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in the triglyceride fraction was carried out by hydrolysis of extracted Nile perch viscera oil with selected lipases with different sn-specificity. It was found that non-sn-specific lipase was the most effective in combined enrichment of both EPA and DHA Ω 3-fatty acids.

Chemical composition of the sediment fractions after thermal and/or enzymatic isolation of oil from salmon bones was determined. It is known that location of phospholipids (PL) is connected to salmon bones. The non-soluble protein-containing sediments and bones of salmon produced in the WP2 were defined as starting materials for isolation of phospholipids. These intermediate materials are thought to have potential health benefits as they contain higher concentration of PL in comparison to salmon filleting co-streams. Almost complete recovery of PL was obtained using ethanol:water mixture as an extraction solvent. The purity of ethanol-extracted PL from wet bone fraction was found to depend on the ethanol: water ratio used. The PL from the wet bone fraction obtained after hydrolysis can be washed out by water. The results have shown that the oxidation quality methods

were applicable for pure salmon PL. However, ethanol isolated PL (industrial technology) contain impurities that impede the measurements. Fatty acid analyses showed that omega-3 fatty acids were more stable in PL than in TAG.

Functional properties of rapeseed protein concentrates in relation to their processing and composition were studied in a selected food application i.e. liquid dispersion ('smoothy-like matrix'). Functionality of plant proteins is often associated with their solubility in aqueous conditions. The commercial rapeseed protein isolate (BioExx) and the protein-rich rapeseed intermediate product produced by dry fractionation and air-classification were compared in a suspension. Project protein concentrate developed in the project was found to be less soluble than the commercial sample of BioExx and its solubility curve as a plotted against pH was clearly different from that of BioExx. In the project product the protein was partly denatured, while BioExx protein was in a native state. The partial denaturation was reflected in the lower solubility under low pH values, but also in the inactivation of endogenous enzymes that significantly increased the stability of the dispersion against colour changes. At neutral pH, most probably the negatively charged carbohydrates in the concentrate slightly increased its solubility due to the resulting high electrostatic repulsions in the system, as observed by zeta potential measurements. Evaluating the denaturation enthalpy of other press-cakes subjected to different processing techniques, i.e. milling and dry milling, little difference was found, which suggested that the major denaturation takes place already before milling. BioExx commercial protein sample possess excellent foaming properties and was used to screen the optimal foaming conditions for food applications. However, the sedimentation of large proteins led to the destabilization of the foam. A micro-fluidization process reduced the size of the particles in the dispersion and more stable foam could be obtained.

Rheological behaviour and effect on microbiological stability of mustard seed press cake fractions were studied in model bread dough and mayonnaise. The fractions served as good thickening agents in low concentrations and inhibited to a limited extent also the growth of moulds and yeasts. The addition of mustard seed fraction affected the smell and taste of the model bread effect being pleasant rather than negative.

Functional properties of the peptide hydrolysates from rapeseed and salmon proteins were investigated in a medical and a skincare application. The development of medical skin care formulation and dressings, according to the needs defined by the market study carried out, was performed. To investigate the functionality and feasibility of the peptide mixtures developed a proof-of-concept of the envisaged skin care materials using model compounds was carried out. Several rapeseed peptide mixtures were tested for impregnation the peptides on diapers. Cream formulations comprising the peptides were applied onto incontinence pads. The bioactive properties of the impregnated pads were tested for selected bioactivities. Impregnated incontinence pad was able to inhibit efficiently the growth of *S.aureus* mainly due to the effect of the cream. Although, the microspheres emulsion containing rapeseed peptides showed slight inhibitory effect on *E. coli* alone, this effect was not, however, perceivable after impregnation of the pads. Environmentally friendly and natural products are a trend in cosmetics. In line with this a novel skin

conditioning nanoparticle formulations based on a simple one-step sonochemical process able to generate stable and small-size carriers for cosmetic purposes were developed. Initially, a proof-of concept for sonochemical generation of biopolymer nanoparticles loaded with active agents was provided. Rapeseed and salmon peptide mixtures were formulated into nanoparticles. Optical microscopy images confirmed the formation of spherical particles. Further stabilization process included the development of nanoparticle emulsions derived from the best peptide mixtures selected. The resulting highly stable nano-emulsions were further studied for bioactivity and compared to their starting solution. The antimicrobial activity, antioxidant activity, anti-wrinkle/inflammatory properties were studied. Generally, all bioactivities were clearly enhanced once transformed into nanoparticles.

WP 4 Technology transfer and demonstrations

Objectives:

The main aim of the work package was to demonstrate the technical feasibility of at least two processing technologies and end-use applications developed in the work packages 1-3. The work package was initially divided into five tasks, but based on the results from the WP 1-3 results as well as the techno-economical calculations carried out in WP 5, only three tasks were initiated. Thus the aims of the work package were:

- To demonstrate the feasibility of production of nutritious components from fish filleting waste for food use in Africa
- To demonstrate the feasibility of the extraction of glucosinolates from rapeseed in India
- To demonstrate the feasibility of the use of fish and/or rapeseed intermediate products in skin care applications

Progress:

Within the three tasks that were initiated both successful and unsuccessful demonstrations were carried out. The technical feasibility of protein hydrolysate production from Nile perch fish filleting residue was successfully demonstrated by SINTEF in Norway as there was no process facilities in the University of Nairobi. Nutrimar showed the reduced bitterness of fish peptides using ultra- and nanofiltration of the hydrolysates from salmon residue. Unfortunately, the hot water extraction of glucosinolates was not successful at pilot scale and the promising results obtained in lab scale could not be achieved before the end of the project. As both TERI and Mecpro are dedicated to finalise the process, development work will continue after APROPOS. The technical feasibility and the great potential of use of fish and rapeseed peptides in skin care applications was demonstrated by the impressive cooperation of SINTEF (preparation of fish hydrolysate), VTT (preparation of rapeseed hydrolysate), UPC (analysis of bioactivities and preparation of nanoparticles from the hydrolysates), TrueC (use of nanoparticles in cosmetics), Texpol (use of nanoparticles in wound dressings) and MAHRN (preclinical studies of peptide hydrolysates).

The production of nutritious components from fish filleting residue was demonstrated by SINTEF using Nile perch obtained from Africa. The filleting of 500 kg of eviscerated Nile

perch resulted 250 kg of rest raw material for the semi-industrial production of Nile perch hydrolysates using a mobile processing unit. Three fractions, oil, protein hydrolysate (FPH) and sediment, were obtained by grinding, thermal treatment and enzymatic hydrolysis of the fish filleting residue. The theoretical yield of dried FPH was 18 kg. However, considerably lower yield was obtained in practice due to material losses in drying. It was demonstrated that this technological solution can be applied for studied raw material for production of nutritious protein ingredient. However, optimisation for several technological steps like separation of hydrolysates, concentration, stabilisation and drying of hydrolysates must be performed before introducing this process industrially. The dried hydrolysates were sent to the APROPOS partners in Kenya (UoN) and Uganda (Lasting Solutions) for use in the food additive formulation. The main objective is to use the food grade fish filleting residue to produce a food additive that is affordable and has the essential amino acids hence can be used to fight malnutrition in the majority of the urban poor.

Hydrolysis and filtration of hydrolysate from salmon backbones was done at Nofima pilot plant at Kaldfjorden in Tromsø by Nutrimar. The aim was to produce hydrolysates with low molecular weight by ultra- and nanofiltration, produce hydrolysates with low bitterness and good taste for further introduction into food matrixes. After enzymatic hydrolysis a traditional thermal separation of the fractions was done. The obtained aqueous mixture of soluble proteins was further treated by a series of ultra- and nanofiltration steps for removal of salt, bacteria, low and high MW proteins and peptides as well as concentration of the wanted peptides. The filtration gave a significant increase in DM, which will make water removal by evaporation easier. Although the enrichment of peptides with the desired size range was not fully successful, the taste of the peptide dry product was low in bitterness, showing that there might have been a partial removal of the bitter amino acids.

The pilot instrumentation for bench scale extraction of glucosinolate from mustard deoiled cake was developed by Mecpro at their workshop and transported to field testing site of TERI. Based on TERI's research on various de-oiled mustard cakes the hot water extraction was chosen as no toxic chemicals (e.g. methanol) was wanted in the process. The mustard de-oiled cake having residual oil content on around 1% was subjected to hot water extraction to separate glucosinolates and protein, hull and carbohydrate fractions. The glucosinolates extract will then be purified for further use as formulation. For pilot run 10 kg of milled and air dried deoiled cake was fed to the extraction unit along with 40 litres of hot water (at 80°C). Unfortunately, the analysis revealed that no glucosinolate was extracted in hot water in the two pilot runs. Past research on glucosinolate extraction from mustard cake at laboratory scale suggests that glucosinolate extraction yield can be close to 0.1% of the de-oiled cake. Thus total glucosinolate which could be extracted from mustard de-fatted cake in India would be around 0.3 million tons/per annum.

VTT prepared a protein hydrolysate by enzymatic treatment of rapeseed press cake for application in skin care formulations. UPC prepared nanoparticles of the most promising protein hydrolysates using ultrasound technique, which is a one-step, fast and environmentally friendly method to generate oil-filled spheres. The nanoparticles were

characterized in collaboration with TrueC and Texpol. The nanoparticles containing rapeseed peptides showed to have bacteriocidal or bacteriostatic effect but no cytotoxic or haemolytic effects. Thus they could be utilised in cosmetic and skin care applications to increase the shelf life of the products and to prevent the wound infections.

WP5. Process evaluation

Objectives:

- To gather relevant information for the assessment of techno-economic feasibility of the developed process concepts
- To evaluate the technical and economic feasibility of the developed process concepts
- To ensure the sustainability of the production process
- To create functional value chain around the novel concepts.

Progress:

Four different processes were proposed and analysed in APROPOS project for utilising fish-filleting side-stream: (i) combined bio-gas and fertilizer production, (ii) thermal treatment of side-stream for production of oil, fish protein concentrate and fish meal, (iii) two-stage process, which applies thermal and enzymatic treatments for producing premium oil, fish protein hydrolysate and fish meal, and (iv) recovery of marine phospholipids from fish bones.

The proposed two-stage process concepts indicated economic advantages compared to industrial applied thermal treatment of fish-filleting side-stream. The main benefit is the higher quality protein hydrolysate, which is also more valuable product than protein concentrate. The feedstock and capital depreciation are the main contributors to the costs. Processes are the most sensitive to the investment cost and changes in product prices. Two-stage processing of fish-filleting side-stream is seen as an attractive option in fish industry value chain in the future. In addition, the first results of recovering marine phospholipids from fish bones with extraction process were promising. This process could even further improve the product range of biorefinery and thus provide additional revenue streams to fish filleting side-stream processor.

Four different process concepts were proposed and analysed for rapeseed press-cakes as well: (i) utilising press-cake as it for feed purposes; (ii) extracting protein from press-cake; (iii) separating anti-oxidative oil from press-cake and (iv) separating glucosinolates from mustard seeds

Rapeseed press-cake is currently used as feed and is a valuable product as such. The proposed high consistency processes showed some advantages over the industrial applied concepts for producing rapeseed proteins from press-cake. In proposed processes the residual oil from cold pressed rapeseed meal is extracted by supercritical fluid extraction technology. This greatly reduces the residual oil content in the meal but the cost for the use

of such technology must be carefully evaluated for economic viability of the business. Economic analysis resulted that the fractionating proteins from press-cake is not currently feasible with proposed technology. Anti-oxidative oil seems to be more promising product, but analysis includes high uncertainty with the estimated value of anti-oxidative oil. In general, higher value products are needed to compensate the cost of feed-stock and variable costs of extraction process. It is assumed that the investment costs of proposed technology are lower than those currently available in the industry.

Significant amount of glucosinolates could be extracted from the mustard press-cakes. This improves the quality of mustard press-cake as feed and allows utilisation of glucosinolates as bio-pesticides. This new process could be attractive option if planned process performance is achieved.

The economic feasibility of biogas production straight from the fish-filleting side-stream was poor. However the energetic value of this side-stream is good and thus the environmental impact of plain biogas production was the smallest. When residues from other proposed fish processes were considered, there were less biogas available from residues and more energy was used for processing the side-streams. In this case there is clear contradiction between the economics and sustainability of new processes. However, the biogas production of residues combined with cattle manure is convenient way to process lowest cost residues streams and to produce additional bio-based fertilisers.

Finally the proposed two-stage process for fish was the most promising technology developed in APROPOS project. Processing rapeseed and mustard press-cakes has also potential, but more research need to be done in order to ensure the economic feasibility. Biogas production from the final residues needs some economic subvention, but can ensure the final target of APROPOS projects –to develop a zero-waste biorefinery.

WP6 Dissemination and exploitation of the results

Objectives:

- To ensure widespread dissemination of project results to public, academia, industry and policy makers
- To ensure exploitation of results
- To ensure proper handling of IPR of project results

Progress:

The main dissemination activities which have been carried out during the project include the maintenance of the project website, project newsletters, press releases, the publications of scientific articles and popular articles in market oriented technical and economic journals and oral and poster presentations at international meetings and congresses. Dissemination has been carried out according to the dissemination plan. The dissemination activities under WP6 are discussed in detail in Section 1.4.2.

APROPOS developed processes and technological solutions which would be applicable for industrial up-scaling already during or shortly after the project. As the project activities have been close to industry and commercialisation, exploitation issues are not discussed in detail. The general exploitation activities under WP6 are described in Section 1.4.3.

Knowledge management was a key issue in the project. The Consortium Agreement contained the rules on how dissemination activities were accepted by the consortium: Planned publications were distributed to all participants and during a time period other participants had a chance to object a planned publication. No patent applications were filed during the duration of the APROPOS project but it is foreseen that a few applications will be filed during the next three years.

1.4 The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

1.4.1 Impact

The APROPOS project has resulted in diverse impacts on the competitiveness, overall sustainability and sustainable growth of the biomass (fish and rapeseed/mustard) processing industries and also of the related value chains, contributing to the goals of the European policy initiatives. The APROPOS ideology lay on the crosswise exploitation of the knowledge on processing and up-grading developed independently in the agricultural and fishery/aquaculture sectors. An essential part of the APROPOS consortium was SMEs. Technological development work carried out was mostly directed to serve the development, competitiveness and future success of the partner SMEs. With regard to SMEs, they are often more agile to take up new technologies and methods than larger companies. Thus the integration of the SMEs into the project's R&D and especially into the technology transfer and demonstration activities resulted in fluent knowledge and innovation transfer from R&D to industrial applications and across the fields of industry, providing the SMEs competitive advantages. Up-grading concepts developed in APROPOS to maximize the exploitation of the selected co-streams will:

- contribute to the economic, environmental and social sustainability of the biomass industry by generating more economic value, ethically more viable uses of our biomass resources and environmental benefits
- enable establishment of small, regionally distributed processing units by developing easily transferable, low-cost processes

Up-grading concepts developed have created business opportunities especially for the SME sector both in Europe and participating ICPC countries, India, Kenya and Uganda. APROPOS has also built a bridge between industries processing agriculture and aquaculture derived raw materials as well as between experts in Europe, North America, East Africa and India.

APROPOS has clearly addressed the issues defined in the 7th Framework Programme on “Knowledge-Based Bio-Economy, KBBE” by exploiting biotechnology-based research opportunities meeting challenges of resource and eco-efficiency and the growing demand for sustainable use of renewable, especially industrially produced, bio-resources from agriculture and fisheries for production of high quality food and cosmetic ingredients, not forgetting the use of the lower value residues to energy, soil improvement and crop protection. APROPOS has created simple water-saving process concepts to produce value-added bio-products and focused on reduction or elimination of waste formation. Renewable biological resources and sustainable use of them are the basis of European KBBE and beyond. A marked European emphasis has put into the development of biorefinery concepts and maximised exploitation of the biomass to chemicals and energy. The main drivers are 1) the climate change and 2) dependency of imported fossil oil, but also 3) the need to create new solutions for handling the co-streams and waste of the food chain, agriculture and fisheries as well as forestry sectors within EU. During the recent years global shortage of food has been anticipated after the time period of approximately 20-30 years, emphasising protein as the main limiting factor. A lot sooner than that the period of soy as the ruler of plant protein market will be over and new challengers, the 2nd generation plant proteins will appear to the market. They are oilseed and legume proteins, perhaps rice. The production of rapeseed residue in Europe is 12 million tons per annum, of which 5 million tons is protein. The protein need of a half of the EU-27 population could be satisfied by this amount of rapeseed protein. Now that the EC has lifted the ban of the novel food regulation of a Canadian canola protein product, the interest towards this nutritive protein has gained a lot of fresh interest in industry also in Europe. APROPOS has been extremely well positioned in this development by developing novel water saving methods to extract protein from the rapeseed press cake residue from cold pressing.

Offering new solutions to exploit good quality co-streams for human consumption was the essential part of APROPOS the other being solutions to exploit the final residues (protein depleted) of the processed co-streams to energy and soil improvement. Provided SMEs, which have been involved in the development work, can build new business on it, they surely cause consequences which are socio-economic, i.e. employment. It is pointed out, that development work carried out and directed to Africa and India, was realised in the demonstration level. To fight malnutrition in East Africa a functional and affordable technological solution to extract and stabilise protein from Nile perch co-stream was demonstrated. This technology can be directly exploited in Africa when/if necessary investments for processing equipment are accomplished. Water-based technology (to replace current organic solvent based) to extract glucosinolates from mustard co-stream was demonstrated in lab scale, good antifeedance effect of extracted glucosinolates towards oriental leafworm moth got the proof-of-concept and a pilot-scale extraction equipment was designed and built. This technology will be taken further by an SME involved in the development work. Biopesticide to be developed will have direct socio-economic effects in the agricultural areas of India.

The European knowledge-based bio-economy includes industrial and economic sectors that produce, manage and otherwise exploit biological resources (e.g. agriculture, food, forestry, fisheries and other bio-based industries) and has an approximate market size of over 1.5 trillion €, employing more than 22 million people. Outcome of APROPOS can support the agriculture (plant oil pressers) and fish processing industry as well as the food and cosmetic industries by contributing to the European Lead Market Initiative for bio-based products. This of course necessitates active dissemination of the results via correct media and in correct forums. In APROPOS close and fluent collaboration between European, East African and Indian SMEs, active in the mentioned industrial sectors, was built. APROPOS will lead to greater integration of research actors and corresponding industries from across the enlarged EU utilising two raw materials, biotechnical processing and expertise in processing industries as well as food and cosmetic/pharma sectors. The project also integrated European players with players of North America, Africa and Asia. APROPOS has contributed to the implementation and evolution of the following European policies and strategies:

1. The European Lead Market Initiative for Bio-based Products

- APROPOS made a technology push by developed new bio-processing concepts for utilization of biomass to high value bio-products, such as food ingredients and supplements, natural cosmetic and pesticide components as well as bioenergy and natural fertilizers

2. Europe 2020 strategy

- APROPOS created some prerequisites for economic and ecologically sound advances in the European fish and rapeseed processing industries through the creation of higher added value products from industrial side-streams. This development work is in line with the goals of Europe 2020 strategy: “Industrial biotechnology: more than just ethanol.”

3. European Environmental Technology Action Plan

- APROPOS developed eco-efficient solutions to convert selected industrial co-streams to components which, when taken to commercial production, increase human well-being.
- APROPOS contributed the Plan by supporting development of eco-technologies to be used in East Africa and India. If successful this activity may lead to investments in environmentally benign technologies leading to increased employment and economic growth within the EU (technology and knowledge provider), but also promotion of sustainable development in these developing countries.

4. EU strategy for Key Enabling Technologies

- APROPOS has developed cleaner and sustainable process alternatives for agri/aqua-food operations by providing biotechnological tools together with

mechanical processing as an alternative for the present chemical processing operations to up-grade the co-stream to biodiesel.

5. Industrial policy in Europe and promoting green employment

- It remains to be seen how APROPOS will contribute to the development of industry and consequently the employment. As for APROPOS, it has surely paved the road by offering an opportunity to a) increase the economic growth due to improved competitiveness of European manufacturers of agricultural and fish-derived raw materials in their processes because added-value (feed/energy, food and cosmetics) can be generated from the current process co-streams, b) create new business opportunities for SMEs focusing on co-stream up-grading and end-use. The employment will be positively affected if co-stream/waste valorization value chains grow intact. The fact is presently, that raw material growers and producers as well as appliers of the added-value end products exists, but the in-between business is not yet there.

The most important socio-economic impacts of APROPOS are based on the project's strong business orientation and developing simple and affordable enough processing methods which can be applied in larger or smaller processing units, also in rural areas and developing countries. All APROPOS industrial partners have stated that they have found new business possibilities due to the access of project's academic results, but also by the new networks and visibility provided by the project partnership. Some participating companies have been able to enter entirely new geographical markets by capitalizing on the APROPOS consortium contacts. As the partner companies are small, the numbers of new jobs created directly or indirectly by the APROPOS project remain moderate.

It is reasonable to consider APROPOS a pioneer project in developing simple and affordable processing solutions and product concepts which are far from rocket science, close to bioeconomy-oriented business and in the very core of the ethically responsible and natural resources-saving processing industry.

1.4.2 Main dissemination activities

The main dissemination activities which have been carried out during the project include the maintenance of the project website, project newsletters, press releases, the publications of popular articles and the presentations at international meetings and congresses. One peer-reviewed scientific article has been published, four manuscripts have been submitted for review and six are in preparation. The main outcome of APROPOS has not been the production of publishable scientific data, but novel and practical solutions for processing selected biomass raw materials to product prototypes. The work executed has been clearly industrially rather than academically oriented. Members of the APROPOS consortium have been invited to give 48 oral presentations and they have displayed six project-related posters. The project will result during 2015 a PhD thesis. Five Master theses have been accomplished during the project. The coordinator

has been interviewed to several popular magazines aiming at the wider public, such as industry and business and policy makers. Communication manager has sent three industrial newsletters in the form of e-mail to targeted organisations including industrial associations and chambers of commerce in Europe, Canada and USA. The first newsletter introduced the APROPOS project, the second newsletter included the second leaflet and the third newsletter advertised the final seminar “The Best of the Rest”.

Three leaflets have been published, one outlining the aims and objectives of the project (first year), the second after the first half presenting the project’s results and the consortium members’ experiences and the third summarising the achievements at the end of the project.

The project website <http://www.euapropos.eu> has been used as a major tool for archiving and sharing of project resources and documentation (password protected staff portal) and for the dissemination of information about the project to the scientific community and general public. The website has been regularly updated with important project information, including publications, standard operating procedures and presentations from project meetings. The web page will continue to run for at least one year after the project has been finished and will eventually be archived and integrated with up-coming projects.

By and large the APROPOS dissemination activities have progressed as planned during the whole project. The project’s main showcase towards stakeholders and external target groups was the final seminar which was organised in the form of a joint event with the FP7 projects TRADEIT and NOSHAN, and the project CYCLE financed by the Norwegian Research Council. The “Best of the Rest” seminar in Potsdam 9th–10th October 2014 brought together over 100 participants from 4 continents and 16 countries.

1.4.3 Exploitation of results

The Industrial Committee representing the SME partners met in connection with every face-to-face project to discuss demonstration activities and exploitable results from the project. A few inventions have been considered as potential foreground IP including bioactive peptide mixtures from rapeseed and fish. The peptide mixtures *per se* are not patentable but their performance in products applications is. Although simple processing solutions to enrich rapeseed protein are not patentable due to limited novelty, there is a lot of industrial interest towards the developed solutions. APROPOS generated valuable raw material and processing to be offered primarily to the consortium SMEs and secondly more widely.

APROPOS has developed processes and technologies according to the plan- Developed technologies were demonstrated and also up-scaled as described below. APROPOS was designed to be a R&D project which would produce technological solutions to be implemented in a short time span.

1. Technology to enrich protein and oil from fish co-stream can be exploited already now as the process does not necessitate major investments. A two stage process to maximise the protein and oil extraction developed in APROPOS will be commercialised in a near future by an SME. A simplified version of the process to produce dry protein powder can be adapted to commercial production also in Africa if the local investments to process equipment will actualise.
2. Dry and water-saving wet technologies to enrich protein from rapeseed were developed. During APROPOS a canola protein product got a permit to enter the European market. This most probably will boost production of rapeseed protein in Europe. To our knowledge at present times there is not a profitable process technology in the industrial scale for rapeseed protein extraction. Major challenges are the complexity of the raw material itself and water intensity of the present processes. As APROPOS has answered to both challenges, it is expected that APROPOS solutions, which are not yet demonstrated in other than lab or pilot scale, will obviously gain interest particularly in Europe. APROPOS solutions are not novel what comes to patenting. Nevertheless, the results obtained are and will be published in scientific journals.
3. Bioactive peptides have been produced from rapeseed and salmon proteins using the state-of-the art enzyme-aided hydrolysis established earlier to fish raw material. Peptide mixtures were found to have several bioactivities and their performance was tested and verified in selected medicinal and skincare products. The bioactivity of peptide hydrolysates results are published as scientific articles, but are not patented. IP of the product applications, however, will be protected. As there is no business so far to produce these peptides in a standardised way, commercialisation eludes for several years.

1.5 The address of the project public website, if applicable as well as relevant contact details

The URL of the project website is <http://www.euapropos.eu/>

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2 USE AND DISSEMINATION OF FOREGROUND

2.1 Section A (Public)

A1: Scientific (peer reviewed) publications relating to the foreground of the project

Published

K. Rommi , T. Hakala, U. Holopainen, E. Nordlund, K. Poutanen and R. Lantto (2014): Effect of enzyme-aided cell wall disintegration on protein extractability from intact and dehulled rapeseed (*Brassica rapa* L. and *Brassica napus* L.) press cakes. J. Agric. Food Chem., 62 (32), pp 7989–7997. DOI: 10.1021/jf501802e. Publication Date (Web): July 21, 2014

Submitted scientific articles

Revilija Mozuraityte, Vera Kristinova, Turid Rustad, Ivar Storrø. The role of iron in peroxidation of PUFA: effect of pH and chelators. European Journal of Lipid Science and Technology.

R. Partanen, J. Sibakov, K. Rommi, T. Hakala, U. Holopainen-Mantila, P. Lahtinen, D. Ercili-Cura and R. Lantto (2014): Modifying the colloidal state of non-refined rapeseed (*Brassica rapa*) protein concentrate by microfluidization (2014) Food Hydrocolloids. The manuscript will be modified and resubmitted to another journal during 2015.

Rivera D., Rommi, K., Fernandes M.M., Lantto, R. and Tzanov T. Biocompounds from Rapeseed oil industry co-stream as active ingredients for skin-care applications (submitted to International Journal of Cosmetic Science).

Rommi, K, Ercili-Cura, D., Hakala, T.K., Nordlund, E., Poutanen, K., Lantto, R., Impact of high-consistency pectinase/ β -glucanase treatment and extraction pH on the recovery and physiochemical properties of proteins from rapeseed (*Brassica rapa* L.) press cake submitted to J. Agric. Food Chem. 11/2014.

A2: The list of all dissemination activities

Papers in Proceedings of a Conference/Workshop

2013

Kangas, P, M. Nappa, R. Lantto, R. Slizyte, K. Navickas. Zero-waste processing of protein rich side-streams. AIChE 2013 Annu. Meet, San Fransisco, CA, US, 2013.

M. Nappa, P. Kangas, R. Slizyte, K. Venslauskas, A. Nekrosius, K. Navickas and T. Remman (2013): Concepts and profitability for utilisation of fish-industry side-stream. Proceedings of the 6th International Scientific Conference Rural Development 2013, Volume 6, Book 3, Kaunas, Lithuania, 28–29 November 2013, pp 95–101.

K. Navickas, K. Venslauskas, A. Nekrošius, P. Kangas, M. Nappa, R. Šližytė, R. Mozūraitytė (2013): Added energy value from application of fish industry co-streams. Proceedings of the 6th International Scientific Conference Rural Development 2013, Volume 6, Book 3, Kaunas, Lithuania, 28–29 November 2013, pp 102–107. ISSN 1822-3230.

K. Navickas, K. Venslauskas, A. Petrauskas, V. Župerka, A. Nekrošius (2013): Biogas yields from food waste. The 12th International Scientific Conference Engineering for rural development, Jelgava, Latvia, 23–24 May 2013, Proceedings, Vol. 12, pp. 417-422.

I. Pranckietienė, R. Vaisvalavičius, R. Dromantienė, J. Aleinikovienė (2013): Assessment of fish processing wastes for the improvement of soil properties. Proceedings of the 6th International Scientific Conference Rural Development 2013, Vol. 6, Book 3, Akademija, Kaunas district, Lithuania, 28–29 November 2013, pp 412–417. ISSN 2345-0916.

2014

Vaisvalavičius R., Pranckietienė I., Dromantienė R., Aleinikovienė J. Soil amendment with fish processing wastes at the low positive temperature regime // Human and nature safety 2014: proceedings of the 20th international scientific-practice conference / Aleksandras Stulginskis University, Vytautas Magnus University, Lithuanian Academy of Sciences. Akademija, 2014. ISSN 1822-1823. D. 3, p. 92-95.

Theses/Dissertations

G. Chalakov (2013): Characterization and upgrading of high-quality co-streams from fish and rapeseed processing industry for cosmetic applications. Master's thesis. University of Chemical Technology and Metallurgy of Sofia, Bulgaria, 12.12.2013.

K. Five (2013): Enzymatic hydrolysis of salmon By-products: Effect of Process Conditions on ACE Inhibiting Activities of Fish Protein Hydrolysates. Master thesis, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, June, 2013, 262 p.

K. Rommi (2012): Enzyme-aided fractionation and analysis of rapeseed press cake components. Master's thesis. University of Helsinki, Faculty of Biological and Environmental sciences. Helsinki, 21.9.2012, 98 p.

R. Skjellegrind (2012): Enzymatisk hydrolyse av lakserygg - Prosessoptimalisering for produksjon av fiskeproteinhydrolysat med antioksidative egenskaper. Student project works at Norwegian University of Science and Technology (NTNU), 29.8.2012.

G. S. Toledo (2013): Fish collagen stabilization by phenolic compounds and enzymes for cosmetic applications. MSc thesis at the Universitat Politècnica de Catalunya. Date of approval: June 17th 2013

Oral presentations in conferences / workshops

2012

K. Navickas (2012): APROPOS – FP7 Project in the field of the Biotechnology// European programmes for Research and Technological Development: What is new? Workshop of Kaunas Chamber of Commerce, Industry and Crafts, Kaunas, Lithuania, 19 March 2012.

R. Thomann, IGV (2012): The Potential of Vegetable Proteins as Meat Analogues and an Ecological Alternative for Health Nutrition. Health Ingredients Europe fair, Frankfurt am Main Germany, 13–15 November 2012.

R. Thomann, IGV (2012): Nutzungsmöglichkeiten proteinhaltiger Kulturpflanzen in Deutschland (Different possible uses of high protein plants from Germany). Visions for use of agricultural raw materials Workshop, Schleswig, Germany. 21–22.2.2013.

R. Thomann, F.Kage IGV (2012): The possibilities for innovative plant protein sources for processing to food and feed. “ExtruAfrica” conference 2013, Nelspruit, South Africa, 23 August 2012.

TrueCosmetics (2012): *Dermocosmetics & APROPOS SKIN Therapy*. 2 workshops, Spain, October 2012.

2013

T. Hakala, K. Rommi, R. Partanen, and R. Lantto (2013): Added value from rapeseed press cake. The 19th International conference on “Capabilities of vegetable proteins”, Nuthetal, OT Bergholz-Rehbrücke, Germany, 15–16.4. 2013. Oral presentation and abstract.

P. Kangas, M. Nappa, R. Lantto, R. Slizyte, K. Navickas (2013): Zero-Waste Processing of Protein Rich Side-Streams. 2013 AIChE Annual meeting, San Fransisco, CA, US, 3–8 November 2013. Oral presentation and extended abstract.

R. Lantto (2014). Added value from rapeseed press cake. The 19th International Scientific Conference on “CAPABILITIES OF VEGETABLE PROTEINS” in Nuthetal, OT Bergholz-Rehbrücke on the 15/16th April, 2013.

R. Lantto (2013): Finland-Africa co-operation – experiences in coordinating an 7th Framework project EU-APROPOS. FinCEAL Workshop on Research Cooperation with

Africa and LAC region in Renewable energy, climate change and biodiversity and tailored training on Horizon 2020, Helsinki, Finland 9.12.2013.

R. Mozuraityte, R. Slizyte, I. Storrø, T. Remman and R. Lantto (2013): Isolation of marine phospholipids from the non-soluble fraction (sediments) after hydrolysis of salmon backbones. 27th Nordic Lipid Symposium in Helsinki, 17–19 June 2013. Oral presentation and abstract.

R. Mozuraityte, R. Slizyte, I. Storrø, T. Remman and R. Lantto (2013): Isolation of marine phospholipids from the non-soluble fraction after hydrolysis of salmon backbones. 43rd WEFTA Conference, 9-11 October 2013, Tromsø, Norway. Oral presentation and abstract.

Mozuraityte R, Slizyte R, Storrø I, Remman T, Lantto R, Isolation of marine phospholipids from the non-soluble fraction after hydrolysis of salmon backbones, International Marine Ingredients Conference 2013, Oslo (Norway) September 22-24, 2013.

Pranckietienė I., Vaisvalavičius R., Dromantienė R., Aleinikovienė J. Assessment of Fish Processing Wastes for the Improvement of Soil Properties // Rural development 2013: the 6th international scientific conference, Aleksandras Stulginskis university. November 28-29, 2013

R. Slizyte, R. Mozuraityte, K. Five and T. Rustad (2013): Bioactive peptides from salmon by-products: with focus on antioxidative and ACE inhibition properties. 43rd WEFTA Conference, 9-11 October 2013, Tromsø, Norway. Oral presentation and abstract.

R. Slizyte, R. Mozuraityte, M. Nappa, T. Remman. R. Lantto, K. Navickas and A.K. Carvajal (2013): Two stages processing of salmon by-products for the high quality product and more profitable and sustainable production. 43rd WEFTA Conference, 9-11 October 2013, Tromsø, Norway. Oral presentation and abstract.

Šližytė Rasa, Revilija Mozūraitytė, Marja Nappa, Tore Remman, Raija Lantto and Kęstutis Navickas, Two stages processing of salmon by-products for the high quality products and more profitable and sustainable production, International Marine Ingredients Conference 2013, Oslo (Norway), September 22-24, 2013.

N. Sozer (2013): Agro side-streams as plant protein sources. Innovation Food Conference iFOOD13, Hanover, Germany, 8–10 October 2013.

R. Thomann, IGV (2013). The possibilities for innovative plant protein sources for processing to food and feed. DLG/Green week Conference and fair, Berlin, Germany, 16 January 2013.

2014

G. Barrabes and D. Rivera (2014). Non-woven swabs for medical skin care application containing APROPOS bioactivities. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

A. Francesco (2014). A new line of cosmetic products based on residues from fish and rapeseed industries. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Tzanko Tzanov, Margarida M. Fernandes, Elisabetta Aracri, Diana Rivera, Rasa Šližytė (2014). Upgrading the co-streams of fish processing industries through nanoparticles formation for skin conditioning purposes. - 8th International Conference on Polymer and Fiber Biotechnology, May 25th–27th, 2014, Braga, Portugal

Hakala, Terhi: "Apropos -hankkeen tilannekatsaus ja tunnistetut liiketoimintamahdollisuudet" by Terhi Hakala at Ruokaketjussa syntyvän jätteen hyödyntäminen Liiketoimintaworkshop, Helsinki, September 4, 2014

R. Thomann, F. Kage and N. Kaushik (2014). Oral presentation and Poster or Publication "Potentials of Mustard Seed – food and non-food applications" at 7th Conference on Medicinal and Aromatic Plant Research, Vienna, Austria. September 14–17, 2014

R. Thomann, F. Kage and N. Kaushik (2014). "Mustard Seed – Ingredients and Processing" at 7th Conference on Medicinal and Aromatic Plant Research, Vienna, Austria. September 14–17, 2014

Lantto, Raija (2014). Invited oral presentation "Added value from rapeseed press cake" in the 7th Protein Summit 2014, Rotterdam, the Netherlands, September 18–19, 2014.

N. Kaushik, R. Skhariya, R. Thomann (2014). By-products of oilseeds (rape and mustard) in food applications. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Nutan Kaushik , Rishu Kalra, and Jagpreet Kaur (2014). Bioefficacy of extracts obtained from cakes of Brassica species against Spodoptera litura. The 7th International Conference on Biopesticides (ICOB 7) from 19 to 25 October 2014 in Turkey.

N. Kaushik (2014). Quality Improvement and and Bioactivity of *Brassica* Species.

Participated in 3rd International Conference on Biotechnology organized by North Maharashtra University Jalgaon 1-5th December 2014.

N. Kaushik (2014). Bioprospecting of Biodiversity for Biomolecules. Indo-Norwegian Seminar organized by Embassy of Norway, India on 21st November 2014.

N. Kaushik, R. Kalra, R. Thomann and R. Skhariya (2014). Utilization of rapeseed–mustard by products for value addition. Symposium on Food and Fuel organized by TERI, India Habitat Centre, New Delhi. 19-20 November 2014.

R. Lantto (2014). The Best of the APROPOS Residues. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

R. Lantto (2014). Reflections and conclusions, joint actions to Horizon 2020. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Kestutis Navickas, Kestutis Venslauskas, Arvydas Nekrosius (2014). Energy balance of anaerobic treatment of fish industry co-streams. Agromek and NJF joint seminar "Future arable farming and agricultural engineering, 24–25 November, 2014, Denmark.

S. Pandey (2014). Piloting: Processing mustard press-cake. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

T. Remman (2014). Future for salmon rest raw materials. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Remman, Tore & Rasa Slizyte, Innovasjon i havbruksektoren: - hva lykkes vi med i gode innovasjonsprosjekter, Fagdag for SINTEF Teknologi og samfunn: "Gjør forskningen vår en forskjell?", Trondheim, Norway. December 10, 2014

Diana Rivera, Margarida M. Fernandes, Katariina Rommi, Terhi Hakala, Raija Lantto, Tzanko Tzanov (2014). Rapeseed production industry's co-streams used as a raw material to develop value-added products: bioactivities and possible applications. 8th International Conference on Polymer and Fiber Biotechnology - Braga, Portugal. May 25-27, 2014

K. Rommi (2014). Transformation of rapeseed press residue into value-added raw materials enriched in protein or phenolics. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Slizyte, Rasa & Tore Remman, Future for salmon rest raw materials, The Best of the Rest, Potsdam-Nuthetal, Germany. October 9–10, 2014

Slizyte Rasa, Elena Shumilina, Revilija Mozuraityte, Alexander Dikiy, Sensitive and advanced technique (NMR) as a tool for identification of quality changes in marine rest raw materials, 44th WEFTA meeting, Bilbao, Spain. June 9-11, 2014

Slizyte Rasa, Elena Shumilina, Revilija Mozuraityte and Alexander Dikiy, Quality changes in salmon rest raw materials followed by advanced NMR technique, Aquaculture Europe 2014, Donostia–San Sebastián, Spain, October 14-17, 2014.

Thomann, Ralph / IGV: Existing results of mustard trials at a 7th Conference on medicinal and aromatic plants, and announced follow up results from APROPOS trials for "The Best of the Rest meeting" at Potsdam to invite experienced participants. Vienna, September 22-23, 2014

Thomann, Ralph, Frank Kage, Nutan Kaushik: Mustard seed: properties and processing in Europe and India, 7th Conference on Medicinal and Aromatic Plant Research, Vienna, Austria. September 14–17, 2014

Tzanko Tzanov, Margarida M. Fernandes, Elisabetta Aracri, Diana Rivera, Rasa Šližytė (2014). Upgrading the co-streams of fish processing industries through nanoparticles formation for skin conditioning purposes. 8th International Conference on Polymer and Fiber Biotechnology - Braga, Portugal. May 25-27, 2014.

Utioh. A., Head, D., Murphy, L. A. 2014. Application of Value Chain Analysis to Fish Co-streams Processing Scenarios. 17th World Congress of Food Science and Technology & EXPO, Sustainability and Food Security, sub-section Food Waste Management, August 17-21, Montreal, Canada.

A. Utioh (2014). Economics: Value chain of utilization side-streams. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Vaisvalavičius R., Pranckietienė I., Dromantienė R., Aleinikovienė J. Soil amendment with fish processing wastes at the low positive temperature regime // Human and nature safety 2014: the 20th international scientific-practice conference / Aleksandras Stulginskis University, 7–8 May, 2014.

K. Venskauskas and R. Vaisvalavicius (2014). Sustainability: Soil improvement and biogas from residues and LCA. The Best of the Rest seminar, 9-10th October 2014, IGV, Potsdam-Nuthetal, Germany.

Poster presentations

2013

Mozuraityte R, Slizyte R, Storrø I, Remman T, Lantto R, Isolation of marine phospholipids from the non-soluble fraction after hydrolysis of salmon backbones, 43rd WEFTA Conference, Tromsø (Norway) October 9-11, 2013

Mozuraityte R, Slizyte R, Storrø I, Remman T, Lantto R, Isolation of marine phospholipids from the non-soluble fraction after hydrolysis of salmon backbones, International Marine Ingredients Conference 2013, Oslo (Norway) September 22-24, 2013.

J. Seppälä, H. Ruuska, R. Slizyte, R. Mozuraityte, R. Kervinen and R. Lantto (2013): General information poster about APROPOS was created and presented by Jaakko Seppälä (Ecofoster Group) at the Marine Biotech conference in Brussels 11th-12th March 2013.

R. Šližytė, R. Mozūraitytė, M. Nappa, T. Remman, R. Lantto and K. Navickas (2013): Two stages processing of salmon by-products for the high quality product and more profitable and sustainable production. International Marine Ingredients Conference, Oslo, Norway, 22-24 September 2013. Poster and abstract.

2014

Kage, Frank, Habel & Voß, Trials with mustard seed in food application: "The Best of the Rest" IGV Potsdam, October 10, 2014.

Rommi K, Hakala TK, Ercili-Cura D, Holopainen U, Nordlund E, Poutanen K and Lantto R. Enzymatic disintegration of rapeseed press cake cell structure improves protein release. Total Food 2014 conference, Norwich, UK November 11-13, 2014.

Press releases

2012

Food industry's high-quality side streams used effectively as raw material for new products, published by VTT, 5 June 2012.

Increasing Utilization of Food Processing Side Streams Key to Improving Health and Sustaining Production, published by MAHRN, September 2012.

2014

Lee Anne Murphy (2014): News release, published by MAHRN "Finding value in co-streams from fish" August 2014.

2015

Kalanperkeistä proteiinituotteita - rypsikakuista ihonhoitotuotteita (in Finnish), published by VTT, 2nd of February, 2015.

Scientists developed protein, skin care and biopesticide products from fish filleting residue and rapeseed press cakes published by VTT, 2nd of February, 2015.

Flyers and newsletters

Project leaflet (2012): Espoo, Finland, 7 September 2012.

Project Newsletter (2013): Espoo, Finland, 8 November 2013.

Project Newsletter (2015): Espoo, Finland, 23 February 2015.

The 1st Industrial newsletter in the form of brief e-mail introduction to the project and APROPOS Leaflet was prepared by Ecofoster and sent to 21 organisations including industrial associations and chambers of commerce in Europe, Canada and USA in 15th December 2012.

The 2nd Industrial newsletter in the form of brief e-mail. Leaflet was prepared by Ecofoster and sent to 27 organisations including industrial associations and chambers of commerce in Europe, Canada and USA in 5th December 2013.

The 3rd Industrial newsletter in the form of brief e-mail. Leaflet was prepared by Ecofoster and sent to 27 organisations including industrial associations and chambers of commerce in Europe, Canada and USA in 28th February 2014.

TrueCosmetics and UPC (2012): Science & Biotechnology in Dermocosmetics. Newsletter, November 2012.

Media briefings

Raija Lantto was interviewed by YLE science journalists about "Ruokaa ja terveyttä sivuvirroista" (Food and health from side streams), VTT, Espoo, Finland, 12.12.2013.

Organisation of conference / workshop

IGV realised a scientific/application conference in April 2013 with 4 different contributions on rape protein (one from VTT APROPOS, one from IGV); Conference title: "Capabilities of vegetable proteins", Nuthetal, OT Bergholz-Rehbrücke, Germany, 15–16 April 2013.

Best of the Rest joint seminar of EU-APROPOS, CYCLE, EU-NOSHAN and EU-TRADEIT, IGV / Potsdam, Germany, 9–10 October 2014.

Other dissemination activities

APROPOS public and restricted website <http://www.euapropos.eu/>

2012

H. Ruuska gave a brief introduction of the APROPOS Project in the Aquatic Resources for Green Energy Realisation "AQUAREL" (Karelia ENPI CBC) project kick-off meeting 8th November 2012, Kostomuksha, Rep. of Karelia / Russian Federation. Audience: AQUAREL Consortium (Finnish & Russian partners) by utilising the APROPOS public website.

2013

R. Lantto gave a presentation "Roskakalasta arvotuotteita": Itämeri ja ruoka (The Baltic sea and food). Toimittajakoulutus-seminaari (Training seminar for journalists), Helsinki, Finland, 7 May 2013.

H. Ruuska and J. Seppälä distributed information on APROPOS to representatives of public authorities, researchers and fish farming companies in the AQUAREL project Opening

Seminar 31st January 2013 at the Karelian Research Centre of Russian Academy of Sciences, Petrozavodsk, Rep. of Karelia / Russian Federation.

J. Sibakov, K. Rommi, D. Ercili Cura, L. Melama, N. Sozer Aykal, T. Hakala and R. Lantto (2013): Advances in emerging plant protein sources. *The World of Food Ingredients*, October/November 2013, pp. 114–117. Article published in a popular press. CNS Media <http://foodingredientsfirst.com/>

R. Thomann, IGV (2013): IGV stand at Food Ingredients Europe fair. Frankfurt am Main, Germany, 19–21 November 2013. Dissemination of APROPOS flyers and information to interested visitors.

APROPOS project was presented both in the form of oral presentation and leaflets during CYCLE (project financed by Norwegian Research Council, No 225349) kick off meeting in Trondheim (Norway), 4-5 April, 2013.

2014

A video clip by SINTEF about APROPOS project (2014). 3.3 min. Available on the APROPOS staff portal website.

R. Skhariya (2014). A video clip by MECPRO about APROPOS project. 5.07 min. Available on the APROPOS staff portal website.

J. Seppälä, Ecofoster, participated at the event “Innovative SMEs under Horizon 2020: towards market's breakthroughs on bio-based industries” 20 February 2014. At the round table discussions of the SME event organised by the European Commission, Mr Seppälä presented his views about participating in FP projects as an SME and ideas on how to encourage SME participation in Horizon 2020. At the event, Mr Seppälä distributed information about the APROPOS project to the other SME representatives. The purpose of the meeting was to better understand the needs and expectations of SMEs under Horizon 2020 in the field of bio-based industries, and to identify actions at EU level that may facilitate SME involvement and maximize the outcomes of their participation.

2015

Raija Lantto (VTT) was interviewed by Niamh Michail from *NutraIngredients* about the APROPOS project. The article was published in the website www.nutraingredients.com/ on February 3, 2015

Raija Lantto was interviewed by Patricia Mansfield-Devine from *Cosmetic Business News* about the bioactive components developed in APROPOS. On February 3, 2015.

Raija Lantto was interviewed by Tarja Halla from the journal *Maaseudun Tulevaisuus* (Future of the Countryside in English) about the developed rapeseed press cake upgrading technologies. The journal is the most circulated newspaper in Finland after the main daily paper *Helsingin Sanomat*. The article will be published on February 28, 2015.

Planned peer reviewed publications

Mozuraityte, Revilija, Vera Kristinova, Inger Beate Standal, Turid Rustad and Rasa Slizyte. Methods for evaluation oxidation status and stability of marine phospholipids.

M. Nappa, P. Kangas, R. Slizyte, K. Navickas, K. Venslauskas, and A. Nekrosius (2014): "Economical and Environmental (LCA) Aspects of Utilisation of fish co-streams". Journal: *Journal of Cleaner production*

Rasa Slizyte, Revilija Mozuraityte, Marja Nappa, Tore Remman and Kestutis Navickas, Two stages processing of salmon by-products for the high quality product and more profitable and sustainable production.

Katariina Rommi, Emilia Nordlund, Raija Lantto et al. Effects of mechanical and enzymatic pretreatment on protein extraction from rapeseed (*Brassica rapa*) press cake.

Slizyte, Rasa; Shumilina, Elena; Mozuraityte, Revilija; Dikiy, Alexander. Quality changes and release of bioactive components during storage of salmon co-streams analysed by advanced technique (NMR) (scientific publication)

Slizyte, Rasa, Rommi K, Mozuraityte R, Eck P, Five K and Rustad T. Bioactive compounds in hydrolysates from salmon rest raw material (2015). The manuscript is under preparation and will be submitted during spring 2015.

Slizyte, Rasa, Elena Shumilina, Revilija Mozuraityte, Alexander Dikiy, Fast and advanced technique (NMR) as a tool for identification of quality changes in marine rest raw materials.