Camelina & crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals

Periodic Reporting for period 1 - COSMOS (Camelina & crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals)

Reporting period: 2015-03-01 to 2016-08-31

Summary of the context and overall objectives of the project

Challenge:
The European oleochemical industry relies on imported coconut and palm kernel oils and fatty acids and castor oil as sources for medium-chain fatty acids (MCFA, C10–C14) and medium-chain polymer building blocks. These are used for the production of plastics, surfactants, detergents, lubricants, plasticisers and other oleochemical products. The challenge is to reduce this dependency.

Overall objectives:
The COSMOS project aims to reduce Europe's dependence on imported tropical oils by turning camelina and crambe into profitable, sustainable, multipurpose, non-transgenic European oil crops for the production of MCFA-derived oleochemicals.

Approach:
Seed properties will be screened and optimised through genetic techniques aiming at high yield, low resource inputs, optimization of the value generated from vegetative tissues, and fatty acid profiles
adapted to industrial needs. Large-scale field trials will be performed at different locations in Europe to assess the potential of the crops in terms of cultivation practices, seed yield, oil content, ease of harvesting, and resource inputs. Extracted oils will be fractionated into various fatty acid types (monounsaturated versus polyunsaturated) by selective enzyme technologies and extraction processes. The enriched monounsaturated long-chain fatty acids so obtained will be converted through chemical chain cleavage processes to MCFA and high-value building blocks. These serve as feedstock for the lubricants and surfactants, and bio-plastics and flavour & fragrance industry, respectively. Polyunsaturated fatty acids (PUFA) will be selectively hydrogenated to produce higher value unusual monounsaturated fatty acids. Biomass oil yield and crop value will be increased significantly by feeding the crop's vegetative tissues such as straw and leaves and press cake to insects producing high-value oils and proteins. Insects will be selected for synergy with the crops, but also for their tolerance to anti-nutritional compounds present in the vegetative tissues, such as glucosinolates. With this, next to the direct substitution of coconut and palm kernel oil, a whole range of other conventional raw materials and products will be substituted additionally. This combined use of all products and co-products is expected to be economically viable and associated with a lot of environmental and social benefits. The overall economic, social and environmental sustainability based on complete life cycles of the whole value chain will be assessed. The impact of the project for Europe will be assessed in terms of value chain potentials for value creation and number of jobs that can be created.

Relevance for society:
Successful establishment of camelina and crambe as a European alternative for imported tropical oils will contribute positively to employment, income and innovation potential of stakeholders in the crops-to-products value chain. The flexibility of the technologies developed in COSMOS allow for multiple uses of the crops, depending on the market situation in food, feed and non-food uses of the crops.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

In the first 18 months of the project, considerable progress has been made in all parts of the value chain, i.e. in plant breeding (WP2), cultivation (WP3), oil fractionation and purification (WP4), growth of insects on crop residues (WP5), and oleochemicals production and application (WP6). Modern breeding methods have been adapted for use with crambe and camelina. Mutants of crambe show a shift in oil composition in the desired direction, i.e. increased levels of monounsaturated fatty acids (MUFA, including erucic acid, C22:1) and reduced levels of polyunsaturated acids (PUFA). Methods to reduce the content of antinutritional factors (i.e. components such as glucosinolates that are currently restricting the use of seed meals in feed) have been developed and are currently being evaluated. Field trials have been conducted successfully in Greece, Italy, Poland and The Netherlands in order to evaluate optimal growing conditions for a multitude of camelina and crambe varieties. The results show that both crops adapt very well to a northern mediterranean climate. Seed yields are typically between 2 and 3 tons per hectare, with oil contents in the range of 30-40%. In Poland, a larger area was used to grow and harvest camelina and crambe for further processing into refined oils and seed meals. The refined oils have been sent to partners in WP4 and WP6, whereas seed meals have been sent to partners in WP5 for insect rearing.
Several fatty acid fractionation methods have been evaluated on laboratory scale. Several methods are able to produce fractions with increased content of the targeted MUFA, although some methods are more effective than others. Furthermore, promising enzymes have been found that may be further modified in order to selectively remove undesired types of fatty acids, thereby enabling the isolation of the desired MUFA fractions.

Crop residues such as straw, press cake and seed meal can be fed to insects, in that way increasing the oil and protein production. First results show that larvae of certain insects can perform almost as well on press cake diets of camelina and crambe as on a control diet. Improved catalysts have been developed which are able to reduce the costs of certain fatty acid chain scission chemistry that is currently too costly. A patent on these new catalysts and improved methods to prepare them has been filed.

Microbial conversion of PUFA to medium-chain fatty acids (MCFA) with an unusual structure is an interesting approach to improve the economics of the camelina and crambe value chains. A first step in modifying certain microorganisms in order to allow them to produce such MCFA has been performed successfully.

A first and vital step to monitor and improve the sustainability of the processes developed in COSMOS has been taken successfully; an intermediate report has been drafted describing the definitions and settings of the integrated sustainability assessment. This work provides a strong basis for subsequent activities aimed at monitoring and optimising the sustainability of the COSMOS concept. Some of the results obtained in the first 18 months have been published or presented at conferences. One patent has been filed.

**Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)**

Many of the results described above have progressed beyond the state of the art, including novel seed lines/varieties, better cultivation conditions for camelina and crambe crops, improved fatty acid separation methods, reduced costs of catalytic fatty acid chain-scission processes, and e.g. novel bio-lubricants with improved properties. The methods and processes used and the products made will be further improved in order to reach our final project objectives. An Exploitation Plan is updated every six months, and is set up in such a way that it provides a 'dashboard' showing the progress of the project in terms of number of exploitable results, ways to exploit the results, technology readiness levels. Expected returns by sales, licenses and services in the year 2025 have been quantified (confidential results). The product portfolio is quite diverse, and several products are estimated to be able to reach a market size above 100 million Euros.