RESULT REPORT

Re-FOOD: International Partnership for Research and Education in energy efficient resource utilization in Food value chains between Norway and India (2017-2020)

BACKGROUND

Re-FOOD has been funded by the Research Council of Norway under the INTPART programme. The plan for the project was to work on developing an integrated approach to deal with the challenges in the field of bioeconomy. This should include sustainable **utilization of food resources** to meet the growing global demand for food and feed ingredients, in an energy efficient and climate friendly way. A goal of Re-FOOD was to **build long-term and interdisciplinary cooperation** between Norwegian partners SINTEF Ocean and NTNU and Indian partners CSIR-CFTRI, IIT Kharagpur, Amity University and BITS Pilani, as well as other industry and governmental stakeholders in both countries. A strong partnership between these partners should enable RE-FOOD to:

- Engage key research; education and industry partners for maximizing the resource utilization in food value chains.
- Contribute to the global challenges related to bioeconomy.
- Facilitate knowledge transfer and mutual learning.
- Promote cooperation through peer-to-peer activities: reciprocal research exchanges; joint Master and PhD programmes with joint supervision; guest lectures and symposiums.

The partnership was planned to include organization of joint symposiums; joint Master and PhD programmes through dual supervision of Master students and PhD candidates; exchange of researchers between India and Norway and student internships in industry. An annual symposium should be organized to disseminate the research; innovation and education results achieved by Re-FOOD as well as an opportunity to create new contacts to strengthen the cooperation on bioeconomy.

RESULTS

Project was divided into 5 work packages covering different areas and activities.

WORK PACKAGE 1: ANNUAL RE-FOOD SYMPOSIUM (SINTEF, NTNU, AMITY, CSIR-CFTRI, IIT)

Text from project description: An annual joint Re-FOOD Symposium will be organized three times during the project period and will form the central part of the Indo-Norway cooperation. The aim is to have a kick-off meeting in New Delhi in March 2017, 1st symposium in Kharagpur, 2nd symposium in Mysore, and the final symposium in New Delhi. Symposiums will feature presentations of scientific results, joint student projects, interaction with Norwegian and Indian industry and local authorities, site visits and exhibitions. Partners will invite their local *networks of industry, government authorities, research, and education to participate. Other interested parties will be mobilized through Innovation Norway.*

Expected outcomes[1] and final results

D1.1: Report identifying local support networks for each partner including suggestions from the Royal Norwegian Embassy and Innovation Norway in New Delhi. From Innovation Norway and The Research Council of Norway based at the Royal Norwegian Embassy in Delhi Arti Bhatia Kumar, Maan Singh Sidhu and Inger Midtkandal have

[1] Expected outcomes as stated in the original project application is given in ***bold cursive***.

been in involved in planning and participation at symposiums and industry visits. They have also helped with identifying relevant industry for the project and helped arrange meetings and visits to these. The reports from the symposiums includes participants and give a good overview of the involved students, researchers, industry and governmental representatives.

D1.2: Proceedings from each symposium, with reports from discussions and presentations. Reports from the symposiums have been published. In addition, minutes of meeting were made summing up presentations and relevant discussions.

WORK PACKAGE 2: RESEARCH EXCHANGE (SINTEF, NTNU, AMITY, CSIR-CFTRI, IIT)

Text from project description: Short-term exchange of researchers between the partner institutes will be an important part of developing the Indo-Norwegian partnership in Re-FOOD. This will increase the mobility of researchers between the two countries and widen their horizon by experiencing challenges related to bioeconomy in a different national and cultural context. Researcher mobility will aim at enhancing the academic and scientific quality of the research projects linked to Re-FOOD through collaborative work with renowned researchers in the field. The mobility will function both ways with researchers from Norway to India and vice versa and with an average duration of two months. Six researcher exchanges are expected in Re-FOOD.

Expected outcomes and final results

D2.1: Reports and presentations from reciprocal research exchanges. Several presentations and lectures have been given during the research exchanges, and information from these exchanges have also been given during the annual meetings and symposiums. From Norway a total of three research exchanges to India was conducted (Maitri Thakur 2017 and 2018, and Guro M. Tveit 2018). Similarly, five research exchanges from India to Norway was conducted (Mihir M. Hazarika 2017, Sandeep K. Singh 2018, Asha Kumari 2019, Khushboo Gupta 2019, Sengnolotha Marak 2019). The work conducted during their stays has been incorporated into PhD thesis, articles and reports.

WORK PACKAGE 3: JOINT MASTER AND PHD PROGRAM (SINTEF, NTNU, AMITY, CSIR-CFTRI, IIT)

Text from project description: Joint Master and PhD programs will be developed between Norway and India. Re-FOOD partners will agree on common topics relevant for both countries with parallel Master and PhD positions at NTNU and Indian partner institutes with joint supervision. During their stay abroad, the project partners will introduce them to industries and facilitate summer jobs and internships where possible. Indian partners have excellent links with the food industry where the students can work as trainees. In addition, the researchers from each country during their mobility stays will contribute as guest-lecturers in the host institution in relevant Master courses. For instance, NTNU has a Master program in Sustainable Food Production and a guest lecturer from India would provide the Norwegian students with a broader perspective on challenges and opportunities related to global food production and the same will hold true for guest lecturers from Norway to India. The Master students and PhD researchers will present their work at the annual symposiums.

Expected outcomes and final results

D3.1: Report on identification of double degree study tracks and joint Master and PhDs and implementation of these opportunities. During the project period several attempts have been made to identify possible joint master- and PhDs programs, but different semesters periods in Norway and India has made implementation difficult. As an alternative approach, 6 students from NTNU went to India as part of their master studies. It was Frida Larsen Holm, Sara Aakre, Kristin Brustad who worked and studied at CSIR-CFTRI, and Erling Vingelsgård, Benjamin H. Espendalen og Tom André Bredesen who worked and studied IIT. The students from NTNU at IIT had project work and master thesis topics defined by IIT, and the results have been presented in three joint conference papers.

D3.2: Guest lectures by visiting researchers at host institutes, six totally (3 guest lectures in Norway and 3 guest lectures in India). During the research exchanges and during the annual symposiums several different guest lectures were conducted. The symposiums were also open for students and faculties. Unfortunately, we were not able to conduct more lectures, as we faced some problems due to the differences in semesters between Norway and India, and some visits collided with ongoing holidays or other religious festivities. However, all symposiums were open for students, and many students attended the two symposiums which were conducted on campus (one at BITS Pilani Goa and one at AMITY university Kolkata).

WORK PACKAGE 4: INDO-NORWEGIAN RESEARCH PARTNERSHIP ON BIOECONOMY (SINTEF, NTNU, AMITY, CSIR-CFTRI, IIT)

Text from project description: Internal project workshops will be organized during annual symposiums to identify future collaborative opportunities in the field of Bioeconomy through different funding mechanisms including the Research Council of Norway (INDNOR program), Horizon2020 (where India is eligible for funding through the Department of Biotechnology and Department of Science and Technology, Govt of India) and EraNets. The results from these workshops will form the basis for new project proposals and future collaboration between the institutes involved in Re-FOOD.

Expected outcomes and final results

D4.1: Report identifying potential for future collaboration in international projects. During the project several potential future collaboration projects have been identified. A growing list of potential future project ideas has been collected throughout the project. The lists are presented in the summaries from the symposiums.

D4.2: Joint proposals for funding for future collaborative project on Bioeconomy through the Research Council of Norway, EraNet INNO-INDIGO, Horizon2020 and other sources. During the project period, several collaboration projects between Norway and India has been specified and applied for within India, Norway or the EU. These are the projects which has been approved until now:

- ReValue
    - Jointly financed by the research council of Norway (NFR project number 281262) DBT (India) and CDTI (Spain)
    - Project led by SINTEF Ocean, participants BITS Pilani, Amity University and others
    - 2018-2021
    - Contribute to achieving the Sustainable Development Goals target on food losses reduction, by developing innovative technologies for the surimi industry
- OMEGA
    - Financed by the research council of Norway (NFR project number 303497)
    - Project led by SINTEF, participants NTNU, Amity university and others
    - 2020-2023
    - Convert fish oil and fish gelatines from farmed salmon rest raw materials, via microencapsulation, into consumer acceptable forms of fortified foodstuff
- INDEE+
    - Financed by Norwegian Ministry of Foreign Affairs
    - Project led by NTNU, participants SINTEF Ocean, Bits Pilani and several others
    - 2021-2024
    - Regulation of refrigerants, field demonstrators of CO2 refrigeration technology in India

WORK PACKAGE 5: PROJECT MANAGEMENT AND NOWLEDGE TRANSFER (SINTEF, NTNU, AMITY, CSIR-CFTRI, IIT)

Text from project description: SINTEF will be responsible for overall management of Re-FOOD with inclusion of

staff that is familiar with Indian cultural context and language. Knowledge transfer is vital for including all partners and engaging external stakeholders. Papers, presentations and reports from each symposium will be collected in proceedings, available to all partners and external stakeholders. The Master and PhD students and as well as researchers will publish joint peer- reviewed journal articles. Short reports about collaborative possibilities with India will also be developed. Researchers that have been part of the Research Exchange will present their scientific work in symposiums. Where possible, guest lectures and other presentations will be recorded into an online database facilitating use of virtual classrooms.

Expected outcomes and final results

D5.1: A collection of joint papers submitted to peer-reviewed journals from Master and PhD students and researchers involved in Re-FOOD. During the project several joint papers have been submitted and approved for publication. Per 31.01.2021, 3 articles have been published. These has been written in collaboration between IIT, SINTEF Ocean, NTNU and BITS Pilani. An additional 5 articles are under preparation, which will be finished and submitted after the project ends.

D5.2: A final project report on opportunities for strengthening the Indo-Norwegian collaboration on Bioeconomy and suggestions for future research and innovation cooperation including industry in both countries. This has been included as a part of the yearly symposium proceedings as well as in minutes of meeting summing up discussions during the yearly meetings and symposiums.

PROJECT PLAN AND RESOURCES

The project started in 2017 and ended in 2020. Most of the activities had gone as planned, however some changes have been made as the project faced problems with travel in 2020, due to the ongoing covid-19 pandemic. Additionally, the project had to make some changes in WP3 for the joint master and PhD programs.

OUTCOMES AND IMPACT

This project has been very successful when it comes to collaboration between Norway and India. The Norwegian research institute SINTEF and university NTNU have had continuously communication with many Indian universities and research institutes throughout the project period. Three symposiums were organized, where all project partners and new relevant participants met. The fruitful discussions both during physical meetings and online gave a very good foundation for further collaboration also beyond the project. This has resulted in many project proposals and the three new projects with RE-food partners: ReValue, OMEGA and INDEE+.

There has been especially close collaboration between this project and the EU Innoindigo project ReValue[2], which focuses on optimizing the surimi value chain through a series of innovations in energy efficient refrigeration, cold chain management and efficient conversion of rest raw materials and wash water into value added protein and oil ingredients for food and feed applications. A seminar was held in Trondheim in September 2019, which included 10 presentations held both by project partners and others, for example the industries Nutrimar from Norway and Kaiko Surimi from India. Lab visits at NTNU were also organized during the seminar, both at the energy and process engineering lab and at the biotechnology lab.

Beside the three RE-food symposiums, there has also been other meetings involving participants from both countries. We have participated in present during NICCI[3] meetings, the Norwegian prime ministers visit to Delhi in 2019, the Indian Business Day in Oslo, meetings with the ambassador of India in Norway and Norad, as well as been present during international conferences like 25th IIR International Congress of Refrigeration, 71st Pacific

[2] ReValue homepage https://www.sintef.no/prosjekter/2018/revalue/

[3] Norway India Chamber of Commerce and Industry www.nicci.no/

Fisheries Technologist Conference, 48th WEFTA and AMIFOST. SINTEF Ocean is also member of NICCI and will participate in their meetings also beyond this project.

There have been several students involved in the project, both on master and PhD levels. Indian students have visited and performed research in Norway and Norwegian students have visited and performed research in India. They have also participated and presented their research and results in the symposiums. All this gave young people a good education in international work and research, which is valuable for their further contribution in the field of research and innovation.

There are differences between the two countries, but there are also many similarities, which becomes clear only through cooperation and communication. This gives a very good foundation for long-term collaboration and further projects together.

There has also been collaboration with other industry and governmental stakeholders in both countries, Innovation Norway and The Research Council of Norway have been important contributors of the success of both this project and future projects.

Three MOUs (Memorandum of understanding) have been signed during this project. The first was between NTNU and BITS Pilani, the second one was between NTNU and IIT Kharagpur and the third one between NTNU and Amity University. The objective of the MOUs is to facilitate further cooperation in research and education. The MOUs are statements of intent to foster genuine and mutually beneficial collaboration. As a general policy, the two institutions shall jointly own results and intellectual property generated.

Several papers including both Norwegian and Indian partners have been published during the project and several more will be published in 2021, for example a monograph on Applications of CO2 based refrigeration systems in food industry, a collaboration between IIT Kharagpur, NTNU and SINTEF Ocean.

COMMUNICATION AND DISSEMINATION

Re-FOOD had dissemination embedded through the annual joint symposiums where project results and experiences were shared with the partners; industry; local support networks and other interested stakeholders. A strong partnership between the SINTEF Ocean; NTNU; AMITY; CSIR-CFTRI and IIT made the project able to engage key research; education and industry partners in Norway and India; stimulate successful practice and facilitate its replicability by facilitating knowledge transfer and mutual learning and documenting ongoing experiences. Especially during the yearly symposiums in Norway and India and research exchanges. The project has also been present during NICCI meetings, the Norwegian prime ministers visit to Delhi in 2019, National Dialogue on “Phasing Down HFCs in India: Incentives and Regulations” in 2019, the Indian Business Day in Oslo 2019, meetings with the ambassador of India in Norway, 2020, and a meeting with NORAD in 2020, as well as been present during the international conferences 48th WEFTA conference (2018), 25th IIR International Congress of Refrigeration (2019), 71st Pacific Fisheries Technologist Conference (2020) and AMIFOST (2018).

During the annual symposiums the results of master students, PhD students and researchers from the research exchanges presented their work and results, joint publications and other cooperation activities. In addition to Re-FOOD partners and local support networks; Innovation Norway offices in India and Norway helped to identify and mobilise relevant industry partners to participate in various events. The project has also had a very active social media presence through Facebook https://www.facebook.com/ReFoodProject and the project webpage https://www.sintef.no/prosjekter/2017/re-food/. The Facebook page has 125 followers, and the most liked Facebook post reached around 700 people.

In total the Re-FOOD project has contributed to the production of 3 scientific articles, 3 symposiums, 3 yearly meetings/workshops, 14 research exchanges (both researchers and students), 3 spin-off projects, 3 MOUs, and a number of reports, poster presentations, oral presentations, popular science articles, Facebook posts, joint Master and PhD supervisions.

REMAINING ACTIVITIES

Results expected to finish after the project has ended:

The collaboration within sustainable utilization of food resources will continue in the three ongoing projects:

- ReValue
- OMEGA
- INDEE+

Partners from Re-FOOD (NTNU and Amity) also sent the proposal *CIC – Crop Improvement Compass* to EU H2020 in January 2021 (coordinated by VUB, Free University Brussels). The result from the review will come in June. This project is about developing a database for improvement of crops that will be a basis for knowledge exchange between all countries and as decision making tools for sustainable agrifood production.

These articles and reports will be published in 2021 (joint publications within other projects)

- Conference paper: Comparison of Energetic, exergetic and environmental performance of a few refrigerant pairs for cascade)
    - Santosh Kumar Saini, Mani Sankar, Dasgupta, Kristina N. Widell, Souvik Bhattacharyya
    - BITS Pilani and SINTEF Ocean
    - iCRAFT 2020 online conference at BITS Dubai in March 2021
- Conference paper: Comparative study of Exergetic and Economic analysis of Multi-evaporator NH3 and NH3-CO2 CRS for a Seafood Processing Plant
    - Santosh Kumar Saini, Mani Sankar, Dasgupta, Kristina N. Widell, Souvik Bhattacharyya
    - BITS Pilani and SINTEF Ocean
    - Purdue conference in May 2021
- Monograph: Applications of CO2 based refrigeration systems in food industry
    - Mihir M. Hazarika, Maddali Ramgopal, Armin Hafner, Ignat Tolstorebrov, and Kristina Widell
    - IIT Kharagpur, NTNU and SINTEF Ocean
    - Published during 2021
- Review: Nutritional and bioactive peptides from fish protein hydrolysates: opportunities, challenges and regulatory issues
    - Nutan Kaushik, Eva Falch, Rasa Slizyte, Asha Kumari, Khushboo Gupta, Veronica Hammer Hjellnes
    - Amity University, NTNU and SINTEF Ocean
    - Submitted 2020
- Research paper: Effect of different drying methods on the nutritional value of Hibiscus sabdariffa calyces as revealed by NMR metabolomics
    - Sengnolotha Marak, Elena Shumilina, Nutan Kaushik, Eva Falch and Alexander Dikiy
    - Amity University and NTNU
    - Submitted 2020
- Two research papers based on PhD student work and results Asha Kumari and Khushboo Gupta (Amity University)
    - Co-authors from NTNU and SINTEF Ocean

Co-supervision of students (joint supervision within other projects)

- Asha Kumari (Amity University) co-supervisor Rasa Slizyte (SINTEF Ocean)
- Khushboo Gupta (Amity University) co-supervisor Kristina N. Widell (SINTEF Ocean)
- Sengnolotha Marak (Amity University) co-supervisor Alexander Dikiy and Shumilina, Elena (NTNU)
- Abdullah Sultan (Bits Pilani) co-supervisor Maitri Thakur (SINTEF Ocean)
- Santosh Kumar Saini (Bits Pilani) co-supervisor Kristina N. Widell (SINTEF Ocean)