4.1. FINAL REPORT FCUB ERA GA 256716

EXECUTIVE SUMMARY

The FCUB ERA project (www.fcub-era.rs) was proposed in order to enable the Faculty of Chemistry, University Belgrade (FCUB) to become a more integrated partner of the European Research Area and to fully unlock its research potential. The proposed project duration was three years and its implementation started in July 2010.

Since the dissolution of Yugoslavia, the Western Balkan region has experienced much political, economic and social turbulence causing great fluctuation in the quality and consistency of the regionôs research. This instability has led to decline in research as the majority of institutes and universities depend solely on the national research funding, which currently stands amongst the lowest in Europe. The FCUB ERA project addressed this deficit, investing in infrastructure and people for the benefit of the region in a way that it can provide sustainability of the research excellence of the centre for food and molecular biotechnology at FCUB. Following a set of coherent measures, massive mobilization of the FCUB research potential has been achieved through exchange of know-how and collaboration with outstanding EU institutions that supported the FCUB ERA project: VTT, Finland, KI, Sweden, INRA, France, RCB, Germany, NHRF, Greece, RWTH, Germany, PPMB, Bulgaria and IRAS, the Netherlands. The project has fully achieved its objectives and goals, providing the key input to the unlocking of the research potential of the institution and its integration into ERA.

Summarizing objectives and achievements so far, research capacity of the institution has been improved by hiring experienced researchers, all the planned major equipment was purchased and implemented by FCUB research groups, joint articles have been published with EU supporting institutions and new joint project proposals have been submitted for financing within various funding schemes. Acquisition and upgrade of the equipment for Protein Analysis and the establishment of a Proteomics Center at the FCUB, first of a kind in the country, Facilities for Molecular Biotechnology, Cell Culture Facilities and Structural Instrumental Analysis Facilities, was achieved. The FCUB organized two international workshops, attended by more than 140 researchers from the country, WB region and EU and an international conference attended by more than 100 researchers. More than 40 seminars have been organized at the FCUB as a follow up of short term training and scientific research missions, know-how exchanges with EU supporting institutions and invited lecturers from other research institutions and industry in Serbia. Most importantly, the quantity and the quality of research publications of the FCUB research groups active in the fields of food science and biotechnology have been significantly improved and above the planned increase.

The project contributed to the regional economic and social development in the area of food research and molecular biotechnology, with a vision to improve public awareness on food safety and health effects of food, thus prompting governmental sector on faster pace development of food and export public policies in accordance with EU legislative regulation. The institution significantly improved quality of its research and capacity to engage in collaborative R&D actions with both academic and industrial partners and become an integral part of ERA.

The core competencies of the FCUB food research centre nowadays are biosciences, the functionalization of foods, advanced analytical methods of food analysis and industrial biomolecules. Research and development is carried out in joint interdisciplinary projects with industry and universities or in the form of work-contract with industrial partners across the

Europe, thus making the necessary climate for functioning of ñacademia-industry-governmental triple helixò.

Please provide a summary description of the project context and the main objectives. The length of this part cannot exceed 4 pages.

The FCUB is centrally located in Belgrade, Serbia, and hence, perfectly suited for interactions with local universities, research institutes and industry, as well as, other institutions and industry in the Western Balkan region. A total of 27,000 square meters are owned by the FCUB, comprising of research and training facilities, as well as, a solid-established IT centre.

In total, FCUB has 147 research laboratories and permanently employs 46 senior researchers and 50 research and teaching assistants. Temporarily-employed staffs include PhD students, hired through temporal contract for research and teaching activities. Although well-equipped for a wide range of chemical and biochemical analyses, FCUB was in the need of more sophisticated equipment, especially for the growing fields of food research and molecular biotechnology.

The first 5-year strategic development program of the FCUB has started in 2003 and has been oriented towards implementation of the molecular and cell biology techniques. This development strategy resulted in the establishment of the first Molecular Biology Laboratory in 2003 and a Cell Culture Laboratory in 2006. In addition, special efforts have been made towards establishing tighter collaborations with institutions active in food and molecular biotechnology research by joining a COST Action in the Domain Food and Agriculture in 2006. Since 2008, the Laboratory for Molecular Biotechnology has been put into gear by joint efforts of the FCUB research staff educated at the outstanding institutions abroad, such as Karolinska Institutet (Stockholm, Sweden), VTT (Espoo, Finland), Research Center Borstel (Borstel, Germany) and Jacobs University (Bremen, Germany).

Starting with the year 2003, management of the Faculty of Chemistry allocated more than 1 million EUR towards building and upgrading facilities in order to support research in the fields of food chemistry and molecular biotechnology. However, compartmentalization of the equipment and research activities within small research groups had been pinpointed as a major obstacle towards achieving strategic goals of the institution development.

A very strong research background of several research groups and more than 45 researchers, of which 14 senior researchers, working within the field of food research and molecular biotechnology, ensured a flexible platform able to cope with complex research tasks in the field of food research, focused on improving the food safety and quality.

Strategic plan of the FCUB development toward becoming the Center of Food Science and Molecular Biotechnology (CFSMB) for the period 2009-2014, involved:

- **Research aiming at improving food safety and quality**: Evaluation and standardization of food allergenic extracts (peanuts, cowôs milk, fruit and vegetables) at the molecular level; development of cutting-edge methods for the determination of trace allergen contaminants in food matrix (MS-based and multiplex technologies based on flow-cytometry).
- **Research in the field of food biotechnology and enzymology**: Development of new enzyme tools for food industry, based on screening, production, preparation and stabilization of enzymes (protease, glycohydrolases, lipases) by techniques of molecular biotechnology and high

throughput screening. Development of new recombinant allergens for an improvement of allergy diagnosis.

- **Innovative solutions for health-improving food; food for health and well-being**: development of new prebiotic and probiotic products for healthy newborns - *In vitro* infant formulae**;** development of nutraceuticals with organically bound trace elements; hypoallergenic food products; healthy diet: development of methods for organically bound oligo- and micro-elements in food.

FCUB ERA project proposed a set of coherent measures aiming at the massive mobilization of the facilitiesô research potential through collaboration with and an active role of the outstanding EU supporting institutions (VTT, Finland, KI, Sweden, INRA, France, RCB, Germany, RWTH, Germany, NHRF, Greece, PPMB, Bulgaria and IRAS, the Netherlands). Strategic partnerships with EU research institutions recognized for their research excellence in the fields of food science and molecular biotechnology were needed to be developed in order to facilitate integration of the FCUB into the European Research Area.

Within the proposed FCUB ERA project, the institution aimed at improving quality of its research in the field of food science and molecular biotechnology and capacity to participate in collaborative actions with EU partners in order to become an integral part of ERA, while also improving cooperation with other centers of excellence in the region of Western Balkan and industry partners in the country.

Significantly improved institutionôs research capacity and research performance would significantly contribute to regional economic and social development in the area of food research and molecular biotechnology, with a vision to improve public awareness on food safety and health effects of food, as well as provide platform able to cope with the most demanding and challenging request by other R&D players in the region.

The main objective of the project was to build the research capacity of the FCUB in the area of food research and molecular biotechnology to a level of excellence similar to that observed in the EU and to make research at FCUB better coordinated, efficient, innovative and attractive to the best of scientists, and hence, establish better opportunity for integration into the ERA.

Main objectives set by the FCUB ERA project were:

- *Building the research capacity of the FCUB by recruiting two experienced researchers.* FCUB at the moment of application had 14 senior researchers (teachers and PIs). Recruited staff would add a value and increase research capacity to 16 senior researchers/PIs. The planned increase in research capacity at the end of the project was set to at least 11%.

- *Reinforcing the research capacity by massive mobilization and training of the research staff*. Several shorter mutual visits (1 visit of 3 months and 6 visits of 1 month) specifically targeting the training of researchers in support to facilities reinforcement, 6 short-term scientific missions (3 months each visit) for the purposes of training of researchers related to food research and molecular biotechnology and several shorter visits for the improvement of managerial and presentational skills. The achievement of this objective

would be reflected in the improvement and increase in publications of the research groups. The FCUB ERA project aimed, by its end, to increase the number and quality of publications for 30%.

- *Reinforcing research facilities to enable cutting-edge research complement and improve existing research facilities*. Acquisition and upgrade of the equipment will comprise facilities for Protein Analysis towards establishing a Proteomics Center at the FCUB, Facilities for Molecular Biotechnology, Cell Culture and Structural Instrumental Analysis Facilities. The facilities would be rounded-up to support research both on bio-macromolecules and small molecules for the purposes of food safety and quality control, as well as the research on new enzyme tools in the food science. This objective would provide rounding up cutting-edge facilities at the FCUB and boosting the research in both applied and basic life sciences in the country.

- *Establishing strategic partnerships, exchanging know-how and experience with outstanding EU research institutions active in the Food, Fisheries, Agriculture and Biotechnology thematic priority domain of the EU*. Those include: VTT Technical Research Centre-Food Biotechnology, Espoo, Finland, INRA, Nantes, France, Institute of Biotechnology, Athens, Greece, RWTH Aachen University, Institute of Biotechnology, Germany, Research Center Borstel, Germany, Karolinska Institutet, Stockholm, Sweden, Institute of Risk Assessment Sciences, Utrecht, the Netherlands, University of Plovdiv, Plovdiv, Bulgaria, by mutual researchers exchange for the purposes of accomplishing collaborative research projects (short term scientific research missions) and mutual visits of senior researchers in order to discuss research projects and collaboration, as well as joint projects applications. The partner institutions would also take active role in training of the research staff to enable the most efficient implementation of the acquired equipment and in dissemination of the projectôs results by active role in workshops and conferences organized by the FCUB. Those measures were planned in order to increase the number of joint research publications with EU supporting institutions.

- *Improving visibility of the FCUB and facilitating knowledge transfer by dissemination and promotion of the results of the project at international, regional and national level and with selected industry partners*. These would be achieved by attending scientific meetings, conferences, publishing in highly cited journals, starting-up a web page, organizing a press conference to inform public and media on the achievements of the projects and possibilities that FCUB can offer to interested research institutions and industry in Serbia and initiating the Food Interest Group within the Serbian Chemical Society. Increased reputation and recognition of excellence by other researchers can be monitored by an increase in the citation index of the project consortium.

- *Improving writing and presentational skills of the staff* by organizing a seminar delivered by an international expert on scientific writing. Improving managerial and presentational skills was planned to be achieved by several visits of senior research staff and managers to EU-partners institutions and their Grantôs offices in order to support know-how exchange on projectsôimplemenatin and management with experienced EU partners. These measures aimed at increasing the number of project proposals, as well as the number of positively evaluated project proposals submitted by the FCUB.

- *Improving the research and training reputation of the institution, as well as its visibility, by organizing two workshops and one conference.*

As an institution involved with education of chemists and biochemists at all levels of education, and also organizing life-long learning education for the chemical teachers and already employed experts, the FCUB was in an excellent position to multiply the effects of its raised expertise and knowledge built during this project. All researchers involved with this project were also involved in undergraduate and postgraduate education at the FCUB and training of junior researchers.

The project would significantly reinforce the S&T potential of the FCUB by supporting and mobilizing its human and material resources, involving the recruitment of the incoming experienced researchers; it would develop and foster strategic partnerships with outstanding EU research institutions working actively in the field of food research and molecular biotechnology who share similar interests with the FCUB. Results of the project would be disseminated at the international, regional and national level. The links with industry and SME would be improved, increasing the FCUB contribution to regional economic and social sustainable development in the area of food research, biotechnology, food safety and quality. Also, capability of the FCUB to participate in European research cooperation, in particular in FP7 projects, would be increased.

The project aimed at promoting top-level research at FCUB with the long-term goal to strengthen the science and research at the FCUB in a sustainable manner for the benefit of the whole WB region.

Please provide a description of the main S & T results/foregrounds. The length of this part cannot exceed 25 pages.

Overview of the main S&T results

The FCUB ERA project aiming to strengthen the research excellence of the Center for Food Science and Molecular Biotechnology at the FCUB started its implementation in July 2010.

At the beginning of the project, six FCUB research groups, involved in the food research and molecular biotechnology field, comprised of 14 senior researchers, faced a decrease in research capacity due to retirement of senior researchers and a brain-drain process.

Since the beginning of the project, three experienced researchers were recruited through the FCUB ERA project in order to support research potential of the institution for the fields of food research and biotechnology (dr Dragana Stanic-Vucinic, dr Nenad Milosavic and dr Katarina Smiljanic). In addition to the recruitment of experienced researchers through the FCUB ERA project, the institution additionally recruited two Assistant Professors in the vacant positions of retired researchers. The recruited personnel with expertise in biotechnology and in high throughput research screening methods gained at one of partnering institutions of the project (RWTH), significantly improved research potential of the institution for the fields of food and biotechnology and strengthened connections with EU supporting institutions. At the end of the project, FCUB had 18 senior researchers active in the fields of food research and biotechnology and the increase in research capacity was 28%.

In the period 2007-2009, research groups of the Center for Food Science and Molecular Biotechnology of the FCUB published 66 articles, of which 16 were published in journals with IF above 2, with total IF 109,3 (average 22 articles/year, IF/year 36.4). Average number of high quality articles (IF above 2.0) was 5.3/year. An increase in the number of articles, quality of articles (total IF) and number of articles with high impact factor for at least 30% at the end of the project (period 2010-2012) were planned.

Periodic evaluation of the quantity and quality of the articles published by FCUB teams was conducted annually and summarized after 18 months of the project implementation and at the end of the project.

It has been observed that the quality of research publications in the first period of the project implementation (2010-2011) was already improved above the planned 30% comparing to the period before the start-up of the project (2007-2009) demonstrating successful implementation of the projectôs Action plan that aimed to increase the quantity of research publications of the FCUB teams.

Concerning the average number of published articles, it increased for 93% for the period 2010-2011 comparing to the period 2007-2009 (42.5 vs. 22 articles/year, respectively). Almost the same increase in the average number of published articles continued in the next period of 2012-2013*: 95% compared to the period 2007-2009 (* denotes first six month of 2013, meaning that

this statistics is not final, expecting further increase in all other quality and quantity article publishing parameters).

Reviewing total impact factor (IF) of the published articles, it gives a value of almost 200 in the period of 2012-2013* (will be higher at the end of the 2013) and 178 in the period of 2010-2011 and that is approximately five times more than in the period before the project implementation. The total number of articles in high quality journals (IF above 2.0) for the period of 2012-2013 and 2010-2011 is 46 and 45 respectively, and increased nine times when comparing it to the previous period. The average IF of journals in which the FCUB research groups published during the period of 2012-2013 is 2.32, steadily being above a very important threshold of 2.0. It is an excellent final result of the project since it is achieved much above planned value, with a potential to grow even more as 2013 approaches to its end.

In quantitative terms, FCUB food and biotechnology research teams of 18 senior researchers (and 30 junior researchers) for the period 2011-2012, contributed with 1.16% to the total publishing activity of the Republic of Serbia in international journals in all fields of natural sciences, social sciences, humanities and engineering. For comparison, in the period of two years (2011 and 2012), 11700 researchers in the Republic of Serbia published 8180 articles in peer-reviewed international journals in all fields of science and engineering, according the report of the National Research Council of the Republic of Serbia, released in July 2013. Thus, group of researchers at the FCUB publishes almost three times more scientific articles annually above the average in the country. Most importantly, waste majority of articles published by FCUB belong the group of high quality publications. Data for the publishing activity of the Republic of Serbia with regard to the split of publications between leading journals of the field and other scientific journals are not available to enable comparison.

However, searching for the publication activity of Serbian research groups in the scientific journal of the highest rank in the field of food science and technology, Wileyôs *Molecular Nutrition and Food Research* (IF 4, 8 ranked 1/123 journals in the field for 2010 and 3/128 for 2011 and 2012) for the last four years revealed an absolute domination of FCUB research groups when it comes to the top-level scientific contributions to the field of food science and molecular nutrition. No other research groups from Serbia published in this journal, while groups from the FCUB contributed with 5 top-level contributions to this prestigious journal in the period 2010-2013. Similarly, contributions to the highly ranked Elsevierôs *Food Chemistry* journal revealed a 30% share of FCUB research groups among total contribution from the Republic of Serbia for the period 2010-2013, with a peak in the year 2013 (60% of share belong to the FCUB research groups). Most importantly, contributions to these prestigious journals are coming from five different FCUB research groups, demonstrating an even distribution of research quality among its members and providing high quality team-laboratory collaboration and a competitive research environment at the FCUB at the end of the project.

During the first period of project implementation all planned major equipment has been purchased and implemented. Acquisition and upgrade of the equipment comprised of facilities for Protein Analysis and establishment of a Proteomics Center at the FCUB, Facilities for Molecular Biotechnology, Cell Culture Facilities and Structural Instrumental Analysis Facilities. The training of researchers has been conducted as planned during the first period of the projectôs implementation. In the second period, all acquired equipment was efficiently implemented and maintained appropriately. Based on the results obtained by implementation of the newly acquired

equipment, 19 articles have already been published in leading scientific journals of the field, 6 articles are under review in the journals and 12 more manuscripts are in preparation for submission. This confirms fast and successful implementation of the equipment and full achievement of this projectôs objective.

Adding to the investment in infrastructure and research capacity, the FCUB ERA project significantly invested into young people and their training. The project supported 20 scientific visits of junior researchers to EU supporting institutions in order to enable know-how exchange and implementation of joint research projects.

Several shorter visits of senior EU experts took place in order to plan and elaborate collaborative research projects and discuss results of the ongoing collaborations, data analysis and evaluation and joint manuscripts writing. Eight short term scientific research visits in duration of up to 3 months have been conducted specifically for the purposes of knowledge exchange in the field of food research and molecular biotechnology and to support collaborative research projects during the first period of the project. In addition, 12 short term research visits in a duration of up to 3 months took place in the period January 2011 ï May 2013 from FCUB to EU supporting institutions with a purpose to enable knowledge exchange in the field of food research and molecular biotechnology and in order to support collaborative research projects.

These exchange activities resulted in joint publications in scientific journals that have already been published in peer-reviewed scientific journals or are in the preparation for the submission. Results of joint research activities have also been disseminated at scientific meetings and conferences. So far, seven publications (with KI, IRAS, VTT, RCB and RWTH) have already been accepted for publication in the leading scientific journals of the field of food science and biotechnology: *Molecular Nutrition and Food Research, Phytochemistry, Journal of the Science of Food and Agriculture, Food and Chemical Toxicology and Applied Biochemistry and Biotechnology* and several more are in preparation for submission.

The FCUB researchers presented their results at 41 international and regional meetings and conferences in the field of food science and biotechnology. The web-site of the project (www.fcub-era.rs) was regularly updated and maintained. The new Food Interest Group was initiated within the Serbian Chemical Society in December 2010, thus allowing exchange of information and promotion of the food science within the largest network of chemistry professionals in the country during the second part of the project and beyond the project lifetime. The citation index of the articles published by the FCUB group of authors in the period 2002-2012 for the last three years (2009-2011) was 683 and in average 227/year, with an increase of more than 89% comparing to the period before the start of the project. Only in year 2012, the articles published by FCUB research groups were cited 309 times (almost 3 times more than the average citation number from the reference period before the start of the project), showing an exponential growth trend.

Seminar, given at the FCUB for improved writing and presentational skills, was attended by more than 60 participants from the FCUB, but also from other academic institutions in the country. Visits to VTT and PPRBs Grantôs Offices have been performed (5 visits, duration of 3 days to PPRB and 4 days to VTT) in order to enable know-how exchange on projectsô management with more experienced EU partners. The FCUB ERA management also organized seminars and workshops open to all FCUB researchers and students in order to transfer knowledge and skills in

projectsô writing and management. More than 30 junior faculty staff attended organized seminars. These activities had a positive impact on the number of proposals prepared and submitted by the FCUB teams. Comparing it to the period before 2009 (only 3 FP projects had been submitted by FCUB, none of them funded), motivation for applying for EU funded projects at the whole institution has dramatically increased: 9 FP7 proposals have been submitted by FCUB researchers. So far 4 have been positively evaluated by the EC, but none of them funded. In addition, four Grant Agreements were signed: Tempus IV (Improving Curricula in Chemistry and related disciplines), NATO funded project for design of Botulinum neurotoxin inhibitors; NIH, USA, research project for development of peptide inhibitors of Botulinum neurotoxin; NIH, USA, research project on multi-targeted compounds. Since the beginning of the FCUB ERA project, the FCUB has been involved in 4 ongoing COST Actions (CM1002, CM1102, CM1105, FA1005), thus enlarging the network and partnership with several institutions from the EU and the USA at that point. A memorandum of understanding was signed with Medical University of Vienna for collaboration in the field of immunoproteomics of vaccine candidate antigens for trachoma. In addition, two spin-off national projects have been obtained with the involvement of experts from EU supporting institutions of the project: KI, RCB, VTT, IRAS and PPRB.

The FCUB organized two workshops in 2010 and 2011 (Food chemistry and biotechnology workshop and Food and health workshop), an international conference in 2012 and press conference at media center, Belgrade. Each workshop was attended by more than 70 researchers, and international conference ñFood, Health and Well Beingò, organized in November 2012 was attended by more than 100 researchers from the country, region and the EU. The conference was followed up by a special issue of the *Journal of the Serbian Chemical Society*, an Open Access journal of the Serbian Chemical Society, to which several of the EU supporting institutions experts contributed with review articles. The special issue was published in March 2013.

Strengthening of the Research infrastructure of FCUB

A direct outcome of FCUB ERA project was rounding up of facilities for advanced protein analysis that enabled formation of the first operative Proteomics laboratory in the country.
A Jasco CD spectrometer and nanoLC-UPLC-HMTF-MS/MS spectrometer (Orbitrap technology) (Thermo-Fisher) for advanced proteomics and metabolomics were purchased, thus making the core of the first Proteomics centre in Serbia. Both pieces of the equipment are unique in Serbia and wider region of WB. New CD spectroscopy-based methods have been implemented by FCUB groups: secondary structure of proteins determination by CD, near CD spectroscopy for determination of protein conformation and CD spectroscopy applications for small molecules chiral properties determination.
Publications with the data obtained by this equipment were published in leading journals of the field: *Biochimica et Biophysica Acta, Planta Medica, Molecular Nutrition and Food Research, Food Chemistry, Journal of the Science of Food and Agriculture*.
Expertise in CD spectrometry brought new collaboration to the FCUB ï with University of Kragujevac, University of Novi Sad, Faculty of Biology etc.
Mass spectrometry of high resolution coupled to UHPLC or nanoLC enabled implementation of proteomics and metabolomics methods by FCUB researchers. These methods have been applied to the problems of chemical analysis of bee honey, ragweed pollen allergens proteomics, exact mass determination of proteins, peptides and small molecules, monitoring of modification of food proteins by various food processing methods, monitoring of decolourization of textile dyes etc. A

Sartorius laboratory bioreactor BIOSTAT Bplus was purchased to allow a small-scale biomass production, single cell protein and recombinant protein production. The bioreactor has been implemented for production of enzymes and recombinant proteins under the controlled conditions. Qiagen Q-PCR was purchased and it enabled RT-qPCR determination of gene expression as well as determination of genetically modified material. RT-qPCR methods were applied for determination of oxidative-stress enzymes in cells and expression of cytokines in cells exposed to dietary polyphenols. A very sensitive spectrofluorimeter (Horiba Scientific) and a semi-preparative HPLC (Agilent) were purchased in order to enable purification and isolation of small molecules and allow implementation of spectroscopic methods in studying interactions of small molecules and macromolecules.

Publications with the data obtained by this equipment were published in leading journals of the field: *Molecular Nutrition and Food Reasearch, Food Chemistry, Journal of Hazardous Materials, Journal of the Science of Food and Agriculture, Journal of Functional Foods, Veterinary Immunology and Immunopathology, Journal of Agricultural and Food Chemistry, Phytochemistry etc*.

In order to support implementation of the equipment, training missions to EU partners were performed, specifically targeting skills needed for succesfull start-up of new research fields by FCUB teams. Broadening of expertise and training was done by several training visits of FCUB senior and junior researchers:

One research visit for 3 months to RCB for getting training in MS and its applications in analysis of proteins and proteomics was performed by Jana Ognjenovic in the period March-May 2011.

One 3-month mission was conducted to IBRB by Dr Milan Nikolic for training in mass spectrometry and other biophysical methods (CD spectroscopy and EPR) applications in biotechnology in April-June 2011.

A one-month visit to VTT was done by Luka Mihajlovic in order to enable training in Maldi-MS of proteins and its applications in the field of molecular biotechnology and new enzyme tools production in the period April 2011.

One month training visit was done to INRA in order to get experience in polysaccharide analysis (pectins and arabinoxylans) by advanced structural instrumental methods (HPLC, spectroscopy and MS). Training was performed by junior researcher Aleksandra Dimitrijevic in November 2011.

One research visit for 1 months to KI for getting training in quantitative PCR and cell culturing skills. (Marija Stojadinovic, March 2011).

Each training visit was followed by a seminar given to junior staff of the FCUB. The seminars were announced at the web site of the project and the instituon, but also by printing posters in order to inform wider auditorium of the Belgrade University. Information was also disseminated to the members of the Serbian Chemical Society. Practical training seminars and demonstrations were organized after the lectures and presentations.

Newly acquired expertise in mass spectrometry brought new important collaborations to the FCUB, such as with University of Kragujevac, Faculty of Pharmacy, Faculty of Biology in Belgrade, Faculty of Veterinary Medicine in Belgrade etc..

Generation of large data sets by proteomics and biophysics studies (such as CD spectroscopy of secondary structure of proteins) also inevitably led to implementation and development of new bioinformatics skills by research groups and thereby tighter collaboration with other reasearch teams of the FCUB that traditionally have had experience and strong expertise in computational

chemistry and biochemistry (such as research teams from the Inorganic and Organic Chemistry Departments). Linking experimental data with theoretical predictions and models, such as molecular dynamics of proteins, prediction of docking sites and binding energies of ligands to proteins estimated *in silico*, have not been possible before the implemenation of the FCUB ERA project. The project thereby mobilized all research capacity of the institution, not only of the teams working in the food science and molecular biotechnology, and enabled synergy of research efforts and expertise from various fields of chemistry towards implementation of complex, multidisciplinary research projects.

Fast uptake of know-how from the EU supporting institutions and broadening of the research network in the country and immediate region has already resulted in scientific publications on the new topics and scientific collaborations that emerged during the project duration (e.g., memorandum of understanding was signed with Medical University of Vienna on the topic of immunoproteomic characterization of trachoma antigens by 2-D PAGE and nanoLC-MS/MS; R&D contracts were signed with leading producers of allergy diagnostic preparations in Europe, Hal Allergy and DBV companies and in the country, with the Torlak Institute, Belgrade, on the topic of characterization of allergenic proteins from food and pollens. Implementation of advanced methods of protein characterization by mass spectroscopy and biophysical methods of protein structure determination (CD spectroscopy and spectrofluorimetry) has enabled a range of new research topics to be introduced at the FCUB, as well as new courses introduced in the education of postgraduate and undergraduate students at the institution.

Additional training missions that could not be planned at the time of project proposal were financed by FCUB or through different fellowships obtained by personal efforts of FCUB junior researchers aiming at the fastest and most efficient training of researchers for the newly acquired equipment, especially for the field of protein mass spectroscopy.

Based on the data obtained by running the newly acquired equipment and implementing cutting-edge methodology, publications in the leading journals of the fields of food science and molecular biotechnology have already been published by FCUB research groups: in year 2012 (4 articles) and 2013 (12 articles), in less than 2 years since the acquisition of the equipment, which points to a rapid and successful implementation of the new methods. Publications were made in prestigious journal of the fields, such as *Molecular Nutrition and Food Research, Food Chemistry, BBA – General Subjects, Phytochemistry.* Besides those that have already been published, many more manuscripts based on the data obtained by implementation of the new methods and use of equipment acquired through the FCUB ERA project are under review at the moment, or in preparation for submission to the scientific journals such as *Food Chemistry, Molecular Nutrition and Food Research, Analytical Biochemistry, BBA – Proteins and Proteomics, Food and Chemical Toxicology*, *Journal of Nutritional Biochemistry* etc.

Free access to the equipment has been provided by FCUB to all interested researchers from University of Belgrade and to the other institutions in the country. Assistence with data acquisition has been provided by skillful research assistants, deducated to run and maintain the equipment. In order to support the equipment maintenance, the Faculty of Chemistry employed three dedicated research assistants to enable flowless maintenance of the core equipment purchased via the FCUB ERA project: mass spectrometer, CD spectrometer, HPLC and spectrofluorimeter.

Research contributions from other teams in the country have already been published based on results obtained by the use of the new FCUB ERA equipment. New methods implemented by FCUB ERA reseachers have been applied to various areas of research, such as medicinal chemistry, microbiology, environmental chemistry, organic chemistry, inorganic chemistry, chemical engineering and chemistry of natural products.

Research capacity

FCUB has increased research capacity by recruiting 3 experienced researchers in field of food research and biotechnology. The exchange visits with all EU supporting institutions have been performed as planned and already resulted in joint publications. Seminars and visits for the purposes of training in writing, presentational and project management skills have been conducted during the first period of the project. During the second period of the project, nine new project proposals have been submitted by FCUB and 4 have been positively evaluated by the EC; 2 spin-off national projects have been obtained from the Serbian national funding agency with contribution of EU supporting experts from KI, VTT, PPRB, IRAS and RCB. FCUB and EU supporting institutions also applied under different funding schemes (such as WoodForWisdom programme (with VTT), EAACI researchers mobility scheme (with KI)) and with the national funding agencies of the EU supporting institutions, such as Finish Academy of Sciences.

During the project duration recruited experienced researchers were involved in all the planned activities aimed at strengthening of research potential of FCUB. They have contributed with 25 articles and four chapters in scientific monographs to the publishing activity of the institution in the period 201-2013. Significant numbers among published articles are scientific papers in prestigious, leading journals from field of food science and biotechnology. In that way, recruited researchers have contributed significantly to increased publishing activity of FCUB. The important part of the published articles represents joint publications with supporting EU institutions and are, therefore, results of reinforcement and improvement of the collaboration between FCUB and European institutes and universities. Regarding extension of collaboration of FCUB with the institutions from the country and abroad, very important were activities of senior researchers on the organization and realization of two workshops in Belgrade and one food international conference. Most importantly, new contracts with the FCUB were provided for all three recruited senior researchers and their full integration into the institution has been achieved successfully. They fully participate in ongoing applications of the institution for new research projects, take part in education and training of junior researchers and PhD students, coordinate R&D projects and contribute to the strengthening of the FCUB international cooperation partner network.

As a result of the entire commitment of senior researchers, the number of application for joint projects in which they are involved has significantly increased. Senior researcher Katarina Smiljanic is involved in the development and validation of immunoproteomics methods at the FCUB as one of senior researchers working on collaborative project with Medical University of Vienna on selection of vaccine candidate for trachoma. Dr Nenad Milosavic has obtained funding for innovation project ñEnzymatic synthesis of lipid-soluble food antioxidantsò for the period 2012-2013 from the Serbian Ministry of Education, Science and Technological Development, in collaboration with Innovative Centre of the Faculty of Chemistry, Ltd. Dr Dragana Stanic-Vucinic is involved in preparation of the research proposal with VTT under WoodWidom-Net plus program, following positive evaluation of the preproposal.

In addition to the recruitment of 3 experienced researchers through the FCUB ERA project, the institution recruited an Assistant Professor in October 2010 (Dr Radivoje Prodanovic), with expertise in biotechnology and high throughput screening research gained at one of partnering institutions of the project (RWTH), thus significantly improving research potential of the institution for the fields of food and biotechnology and strengthening connections with EU supporting institutions. In addition, in 2010, senior teaching assistant Dr Natalija Polovic was promoted into Assistant Professor Position at the FCUB, after having been at the postdoctoral research stay in duration of two years at the Karolinska Institute, another EU supporting institution of the FCUB ERA project. These recruitments and promotions additionally strengthened connections with EU partners of the FCUB.

In 2012, because of the retirement of Prof. Ratko Jankov, Faculty of Chemistry recruited Assistant Professor, dr Vladimir Beskoski, with expertise in environmental biotechnology and microbiology. Thus, at the moment, FCUB Centre for Food Science and Molecular Biotechnology (CFSMB) has 18 senior researchers working actively in the fields of food research and biotechnology. In 2013, following upgrade of research facilities and research potential reinforcement, Centre was re-organized into five units: Food Analysis Unit (senior researchers: Zivoslav Tesic, Dusanka Milojkovic-Opsenica, Dragan Manojlovic, Jelena Mutic, Maja Natic), Food Biotechnology Unit (senior researchers: Miroslav Vrvic, Ljuba Mandic, Jelena Acimovic, Vladimir Beskoski), Molecular Biotechnology Unit (senior researchers: Marija Gavrovic-Jankulovic, Nenad Milosavic, Radivoje Prodanovic, Natalija Polovic, Milan Nikolic), Proteomics Unit (senior researchers: Tanja Cirkovic Velickovic, Dragana Stanic-Vucinic, Katarina Smiljanic) and Food Enzymology Unit (senior researcher: Zoran Vujcic).

Research at CFSMB is funded mostly through research projects obtained from the Ministry of Education, Science and Technological Development of the Republic of Serbia. CFSMB groups were successful in raising funding for scientific research. At the moments six collaborative research projects are funded for the period 2011-2014 and coordinated by T. Cirkovic Velickovic, M. Gavrovic-Jankulovic, Z. Vujcic, Z. Tesic, D. Manojlovic and M. Vrvic. In addition, two innovative projects in duration of 12 months (2012-2013) are obtained and coordinated by N. Milosavic and D. Milojkovic-Opsenica. Additional funding for research has been obtained through international collaboration: with Medical University of Vienna (participation in the OCUVAC project of the Medical University of Vienna), leader T. Cirkovic Velickovic; with NATO funded project for Botulin neurotoxin inhibitors (leader B. Solaja, T. Cirkovic Velickovic, team member) and through cooperation with industry in the country and abroad (Hal Allergy, Holland and Institute for Food Science, Serbia).

Several short term scientific missions also took place during the project duration for the purposes of conducting research on specific collaborative research projects, discussing joint research projects, and exchanging know-how. Both junior and senior research staff of the FCUB took the opportunity to visit EU supporting institutions and perform specific research projects in order to gain skills in the field of food research and molecular biotechnology, but also to take advantage of advanced know-how offered by the EU collaborators. Each STSM visit was followed by a seminar at the home institution, or by a lecture given by a visiting expert. Supported by the FCUB ERA project, were more than 50 seminars, lectures, training sessions, practical demonstrations and presentations delivered at the FCUB and announced via the web-site of the project and by publication of poster announcements.

Mutual visits of researchers transfer of know-how and experience in molecular biotechnology:
Mobility to get knowledge and experience in lipid oxidation, oxidative enzyme activities, free radicals and antioxidants in plants and food: 1 senior researcher (Milan Nikolic), 3-month visit to IBRB, Athens, Greece (July-September 2011).
One 3 month research period in gene mining technology, protein engineering and heterologous expression of enzymes in yeast to RWTH, Aachen, Germany (Jana Ognjenovic, May-July 2011).
One 3-month (Jelena Radosavljevic) stay at the PPMB, Plovdiv, Bulgaria for the purposes of gaining knowledge in plant biotechnology and data mining by bioinformatics (July ï September 2011).
One 3-month research training at RWTH, Aachen, Germany, in heterologous expression of enzymes in yeast (Milica Grozdanovic; May-July 2011).
2-month training at IRAS in order to enable introducing novel methodologies in risk assessment to new or modified foods (Marija Stojadinovic; November-December 2011).
2-month training at KI in cell culturing skills and expression of proteins in mammalian systems (Luka Mihajlovic October; November 2011).
1-month training at INRA in analysis of cell wall polysaccharides present in *alcohol insoluble material* (AIM) from apple and tomato (Aleksandra Dimitrijevic; December 2011).

Additional STSM conducted were conducted during the first period of the project in order to support new collaborations between FCUB and supporting institutions:

- 1 month visit to INRA by Aleksandra Dimitrijevic in order to improve knowledge in glycosides separation and analysis.
- 2-month visit to KI by Marija Stojadinovic for the analysis of the influence of modern food processing technologies, i.e. high intensity ultrasound and cross-linking enzymes, on allergenicity of beta-lactoglobulin.

In the second part of the project, STSMs were conducted in order to enable joint research projects that will deliver joint publications between FCUB and EU supporting institutions and enable further transfer of knowledge between partners.

- 2-month research visit to RWTH. Topic: Purification and characterization of mutants of cellulase, created after conducting the experiment of directed evolution and generation of mutant library. (Jelena Acimovic, January-March 2013).
- 2-month research visit to KI. Topic: Analysis of red meat degradation pattern in simulated gastrointestinal conditions. (Danijela Apostolovic, January-March 2013).
- 1-month research visit to VTT. Topic: Maldi-Tof analysis of intact bacterial cells (Vladimir Beskoski, February 2013).
- 2-week research visit to IRAS. Topic: Tight junctions degradation by actinidin: in vivo assessment. (Milica Grozdanovic, January 2013).
- 2-week research visit to IRAS. Topic: Estimating native and cross-linked ɓ-lactoglobulin (BLG) bioavailability *in vivo*; (Marija Stojadinovic, January 2013).
- 1-month research visit to RCB. Topic: Investigation of the cytokines produced by epithelial cells upon exposure to food and inhalant allergens. (Marija Gavrovic-Jankulovic, July 2012).
- 2-month research visit to INRA. Topic: MRM quantification and neosequencing of food proteins. (Luka Mihajlovic, September 2012).
- 3-month research training at INRA in purification and characterization of enzymatic activities for the purposes of the controlled implementation of enzymes in engineering of

food matrix proteins and polysaccharides with targeted properties (Jelena Mutic, April-June 2012).

- 2-month research visit to INRA. Topic: Diffusion of molecular probes in cell wall mimicking matrixes. (Jasna Nikolic, March-April 2013).
- 1-month research visit to INRA. Topic: Development and validation of an HRMS method of protein quantification in Brachypodium distachyon seeds. (Jelena Vesic, January 2013).
- 2-month research visit to KI. Topic: Investigation of IgE-binding properties of milk-derived peptides by digestion in simulated gastric conditions. (Jelena Radosavljevic, January-March, 2013).
- One 3-month research visit to RCB/ Topic: Construct of banana lectin (BanLec) with two major inhalatory allergens (Bet v 1 and Der p 2): cloning and expression (Milica Grozdanovic. February-April 2012).

During the second period of the project, 12 visits were conducted in order to enable transfer of knowledge. All the STSMs were prepared in coordination with host supervisors at the EU institution.

Exchange activities, as well as reinforcement of FCUB research potential by hiring two Assistant Professors, directly from two of the EU supporting institutions (RWTH and KI) in October 2010, facilitated publication of joint articles with EU supporting institutions and implementation of new methods in the fields of food science and biotechnology:

In addition, number of students writing a thesis on the topics connected to the project has doubled in year 2012, comparing it to the year 2011 or year 2010 demonstrating an increase in interest of young researchers for the field of food science and biotechnology.

The analysis of the published articles revealed that new keywords in renowned scientific journals can be grouped into:

1. New subjects of research (new food and agricultural products analyzed, new food processing methods, new compounds, nutraceuticals, proteins, allergens);

2. Diversification of research (food biotechnology and enzymology products, such as novel enzymes, novel microorganisms, food allergens discovered; novel health effects of food);

3. New methods based on implementation of projectôs equipment (especially mass spectrometry, CD spectroscopy, cell biology methods and spectrofluorimetry).

The focus of the FCUB ERA project was also on improving writing and presentational skills of the staff by organizing a seminar given by an international expert on scientific writing and also to improving managerial and presentational skills by several visits of senior research staff and managers to EU-partners institutions and their Grantôs offices.

We proposed that this measure will increase the number of project proposals, as well as the number of positively evaluated project proposals.

Before 2010 the FCUB had 3 proposals submitted under FP6/FP7 from the FCUB, none of them granted. One of the proposals was on the waiting list for financing after positive evaluation by the EC.

In order to improve writing and presentational skills of the staff, a seminar was organized at the FCUB In April 2011, ñStructure of scientific articleò. Guest lecturer was Vojislav Pejovic and seminar was attended by more than 60 junior and senior researchers from the FCUB, but also from other institutions of the University of Belgrade. In this course, the basics of a successful treatment of research articles were addressed:

- critical appraisal,
- substantive editing,
- composition of an abstract, and
- composition of an outline.

Goals of the course were:

- Evaluate research design and activities, and determine the internal validity of study's results and conclusions
- Identify the critical parts of a manuscript and ensure the consistency of data in all parts
- Identify potential errors and biases that may distort the results or interpretation of the study
- Identify and correct ambiguities and inconsistencies in the text, tables, figures, and references of scientific research manuscripts
- Make text, tables, and figures more efficient and effective.

All participants participated in the final exam and were given a certificate on the successful completion of the course.

Visits to VTT and PPRBs Grantôs Offices have been performed (5 visits, duration of 3 days to PPRB and 4 days to VTT). The FCUB ERA management also organized practical seminars and workshops open to all FCUB researchers and students in order to transfer knowledge and skills in projectsô writing and management. More than 30 junior faculty staff attended organized seminars. Comparing to the period before 2009 (only 3 FP projects had been submitted by FCUB), motivation for applying for EU funded projects at the whole institution has been dramatically increasing: 9 FP7 proposals have been submitted by FCUB in the period 2010 - 2013 and so far 4 have been positively evaluated by the EC.

Since the beginning of the FCUB ERA project implementation, FCUB researchers were involved in 4 ongoing COST Actions thus additionally enlarging the network and partnership with several institutions from the EU and the USA at that point.

EU supporting institutions of the FCUB ERA project: Karolinska Institutet, INRA, Research Center Borstel, VTT, Institute of Risk Assessment Sciences and University of Plovdiv, RWTH) actively participated in applications for new projects with FCUB. So far, 4 joint proposals with

EU supporting institutions have been submitted for evaluation under various funding programmes of FP7 (FoodTune, BioResInco, CERES, EyeVax), of which two were positively evaluated, but not funded; and two spin-off national projects (coordinated by prof. R. Jankov (prof. M. Gavrovic-Jankulovic, after his retirement) and Prof. T. Cirkovic Velickovic) have been proposed and funded was obtained from the Serbian national funding agency (2011-2014 is funding period).

EU supporting institutions of the FCUB ERA project involved in biomedical research (Karolinska Institute, Sweden and Institute of Risk Assessment Sciences, Holland) also supported capacity building applications of other FCUB research groups, towards building capacity in the field of biomedical applications (2 RegPot applications: BioActive and BioActiveDrug proposals). Moreover, management of the FCUB ERA provided support and help to other research groups in the institutions, as well as to other University of Belgrade research centers, thus spreading know-how and experience gained through implementation of the FCUB ERA project and multiplying the effects of know-how building in projectsô proposals writing and management.

FCUB researchers also supported applications of EU colleagues towards obtaining funding from their national funding bodies (Finish Academy of Sciences application from VTT was submitted in October 2012; WoodWisdom-net Plus application, coordinated by VTT, pre-proposal was submitted in April and it was positively evaluated). There was also a European Academy of Allergy and Clinical Immunology application of a junior FCUB researcher for a 12-month research stay at Karolinska Institute. This application has been granted and it will contribute to sustainability of scientific collaboration between FCUB and KI.

There has also been an increase in the number of requests by public bodies to engage in further collaborative actions from the start of the project till today. Only new collaborations were listed below:

Medical University of Vienna (Austria), 2013, immunoproteomics collaboration (MoU signed in 2013), joint FP7 proposals preparation (submitted in 2012); joint collaborative projects (Laura Bassi Center of Expertise); Interests in bilateral projects Croatia-Serbia: Faculty of Agriculture, Osijek (Croatia), 2013, Characterization of honey; Interest in bilateral projects Italy-Serbia: Department of Chemistry, University of Milan: Agriculture and food technologies, topic: Quality of honey, 2013; University Pediatrics Clinic, Belgrade: Microbiom-2013; University of Mostar (Bosnia and Herzegovina), 2013: The joint appearance on ñHorizon 2020ò. Environmental microbiology; Ministry of Agriculture of the Republic of Serbia ï IPA project: Defining geographical origin of Serbian wine, 2013; University of Nebraska, USA, Peanut digestion resistant peptides characterization by mass spectrometry, 2012; Kinno Ltd, SME from Athens (Greece), Joint FP7 INCO proposal preparation (submitted in 2012); Faculty of Pharmacy, University of Zagreb (Croatia)-Applied Microbiology-2012. Institute of Neonatology, Belgrade: Development of new human milk fortifiers-2011 Faculty of Mining and Geology, Belgrade: Geomicrobiology-2011; University of Illinois in Chicago, Chicago (USA); joint NIH applications; protein-polyphenol interactions ï structure and function relationship; Faculty of Sciences-Chemistry, Kragujevac (Serbia): Bioactive substances from microorganisms and plants-2011; Faculty of Technology, Leskovac, University of Nis (Serbia): Biochemical engineering of new bioreactors-2011; Faculty for Environmental Protection, University ñEducinsò, Novi Sad (Serbia): Environmental biotechnology-2011; Institute of Public Health, Zagreb, Croatia;

Characterization of honey; Faculty of Agriculture in Osijek, Croatia, Characterization of honey; Biotechnical Faculty, University of Ljubljana, Slovenia; Characterization of honey; Institute for Biological Research, Serbia, Polyphenols characterization; Proteomics; Faculty of Biology, University of Belgrade, Serbia, Proteomics and semi-preparative purification of cyclic antimicrobial peptides; Faculty of Pharmacy, University of Belgrade, Serbia, Department of Bromatology: proteomics, protein analysis, food allergens characterization, food supplements.

All these activities enabled strengthening and sustainability of the research network formed during the FCUB ERA project and provided means for continuation of scientific collaboration in the field of food science and molecular biology. In addition, valuable experience has already been gained by working together on collaborative proposals applications with EU institutions.

FCUB research groups working in the field of food science and biotechnology have actively working on raising funds for research activities.

The research teams of the FCUB obtained five collaborative projects, one large collaborative project and two innovation projects from the national funding agency. In total, more than 2.5 M EUR was raised for funding research activities since the beginning of the project, of which nearly 1 M EUR was requested and granted for further upgrade of research facilities for food science and biotechnology. Thus, research facilities have been further upgraded in year 2012 and 2013 from the national research funding sources, thus providing synergy between national and European funds for facilities reinforcement.

Full reintegration of recruited researchers was achieved and new contracts were provided (in February, May 2013 and the third contract in July 2013) within the research projects coordinated by FCUB and funded by the National Funding Agency of the Republic of Serbia. The recruited researchers contributed to the publishing activity of the institution with 25 articles in international scientific journals and four chapters in the scientific monographs. They actively participated in organization of the workshops and a conference organized within the project and contributed to the increased reputation of the institution by delivering invited talks at the scientific meetings. The added value to the institution was also reflected in three PhD theses conducted under the supervision of recruited researchers (Nenad Milosavic and Dragana Stanic-Vucinic) and one innovation project obtained by dr Nenad Milosavic for the period 2012-2013. All recruited researchers also took part in joint proposals preparation with EU supporting institutions of the project.

Increase in visibility and reputation of the institution

The FCUB researchers presented their results at 41 international, regional and national meetings and conferences in the field of food science and biotechnology. Active dissemination activities of the FCUB contributed to an increased recognition of scientific excellence of FCUB researchers, reflected in a raised citation number by other authors. The citation index of the articles published by the FCUB group of authors in the period 2002-2012 for the last three years (2009-2011) was 683 and in average 227/year, with an increase of more than 89% comparing to the period before the start of the project. Only in year 2012, the articles published by FCUB research groups were cited 309 times (almost 3 times more than the average citation number from the reference period before the start of the project), showing an exponential growth trend.

FCUB is already recognized by excellence in innovation at the national level. Two research teams of the Center for food science and molecular biotechnology (CFSMB) at FCUB awarded First and Second Prize for the best technological innovation at the national competition for the best technological innovation in 2010. Competition involved more than 150 national teams from all fields of technological innovation. Two technologies were presented: ñModified immobilized invertase in production of inverted sugarò, and ñIn situ bioremediation of polluted soilò. The CFSMB team also awarded the First Prize in innovation at the Nikola Tesla competition for the best product and best innovation in 2011.

At the moment FCUB management is preparing the application for the Status of the National Centre of Excellence in Research for the fields of Food Science and Molecular Biotechnology.

Strict requirements for the national status of excellence, such as high percentage of top-level scientists, number of highly-ranked publications in leading journals of the fields, international collaboration with academia and industry, success in organizing scientific meetings, conferences and advanced training schools **have already been achieved as an important part of the FCUB ERA project**. So far, in the Republic of Serbia, only four centers of research excellence have awarded this important national label in any research fields, from humanities to engineering. With a national label in research excellence, additional annual funding will be available in support of research excellence of the Centre. Successful results of FCUB ERA project, as well as overall progress in last few years, are more than convincing to show that FCUB is ready to be recognized for its excellence and to get the Status of the National Centre of Excellence in Research.

Even before FCUB ERA project, few FCUB groups have started collaboration with EU partners and, as they have recognized our knowledge and efforts to join EU scientific community, they decided to be involved as supporting partners in application for FCUB ERA project. During FCUB ERA project our partnership evolved and now they regard us as equal partners able to complement top level research with mutual benefit. Equipment purchased by FCUB ERA project, as well as short scientific missions to partner institutions, significantly enhanced development of initiated collaborations, which resulted in scientific publications in top level journals, as well as several applications for new projects.

With state of the art equipment and acquired new knowledge and skills, FCUB gain position to further expand collaboration with new EU, as well as non-EU partners. As FCUB demonstrated enviable competence in the field of food science and biotechnology, through already established collaborations we gradually started to generate network of collaborations. FCUB ERA project also had role for FCUB groups with no previous collaborations with EU partners to realize importance of collaborations for their own progress, and it become springboard for mentioned groups to start collaborations. One of the main tasks in the future will be to constantly work on sustainability of established collaborations with EU partner institutions and to get support for it. Support for carrying out joint collaborative actions with EU partner institutions will be also through personal fellowships available for young researchers, such as research award from European Academy for Allergy and Clinical Immunology, FEBS research fellowships, and similar.

From beginning of FCUB ERA project there have been an increased number of postdoctoral requests from researchers, mostly from India, China, Romania and Tunisia, and several research visits have been conducted in the period from the start of the project. We plan to further encourage visits of researchers from abroad and host them; as such visits can result in broadening of scientific network in the future.

During FCUB ERA project there was number of stays by external researchers from EU supporting institutions of the FCUB project who gave lectures, seminars and courses at FCUB. As all these visits have shown to be highly beneficial for the institution and lectures delivered at the FCUB were attended by junior researchers also from the other research institutions in the coutnry.

As of July 2010, a web-site of the project www.fcub-era.rs was initiated in order to disseminate information about the FCUB ERA project, activities and FCUB research teams expertise. A bilingual web-portal wasalso created within the web-page of the FCUB with the relevant information on the project and with a forum established to support discussions and offer interactive communication with the interested research community, industry and public. Web-site of the FCUB ERA project, was continuously maintained and updated.

The web-site offered a detailed presentation of facilities at the FCUB and research expertise of its staff, together with servicing it can offer to community. It facilitated the education of the public regarding the importance of food quality and safety, with a special forum on the increasing problem of food allergies. The web address of the project was also included in the web page information of all the FCUB research staff involved with this project, web-site of the institution in order to allow for better dissemination of information regarding the project and the research expertise of the institution. The web-site content has been regularly updated and contained information on all ongoing activities of the FCUB ERA project, such as seminars, workshops, lectures, researcher's recruitment and trainings organized by FCUB ERA.

Two workshops and a conference were organized in order to disseminate the results of the project and to spread the expertise and knowledge to other researchers in the country and the region:
The 1st FCUB ERA workshop took place on 31st January-1st February 2011 in Belgrade, Serbia.

The theme of the workshop was: **Food safety and health effects of food**

The venue of the workshop was at the Faculty of Chemistry, University of Belgrade, Studentski trg 16, Belgrade, Serbia.

The meeting topics (sessions) were: clustering food research activities in the region of Western Balkan and EU neighboring countries, health effects of food, biochemistry and molecular biology of food allergens, probiotics and prebiotics, food proteomics and metabolomics, nutrition and immunology. In addition, a small symposium with invited industry representatives took place after the sixth session of the workshop.

During the first session, clustering food research activities, FP7 RegPot projects in Serbia in the field of food research were presented (FCUB ERA and CefSer). A guest lecturer from High Institute of Food Industries, Tunis, presented ongoing R&D activities in one of EU neighboring

countries (Tunisia). In total, 70 participants attended the workshop representing 27 different institutions (17 institutions from abroad and 10 from Serbia). The highest number of foreign delegates came from neighboring countries, Romania and Croatia. A special attention was given to poster sessions. The Scientific Committee attended the poster sessions (27 posters were presented in front of the Lecture Hall) and decided on the best poster presentations.

Second workshop tentative topics planned: Enzyme tools in food processing, Proteomics technology in food research, with a forum organized for invited food industry representatives.

The 2nd FCUB ERA workshop took place on 18th - 19th October 2011, Belgrade, Serbia. The theme of the second workshop was: **Food Chemistry and Biotechnology.** The second workshop was attended by more than 70 participants from 19 different institutions (14 institutions from abroad and 5 from Serbia). The highest number of foreign participants came from Romania, Greece, Tunisia, Poland and Belgium.

An international conference was organized in November 2012. The Belgrade Food International Conference workshop took place on 26th - 28th October 2012, Belgrade, Serbia. The theme of the conference was: Food, health and wellbeing. The Conference was organized in eleven sessions and two poster sessions: Enzymes in food processing, Wastes and biomass valorization, Supplements, micronutrients and food additives, Food antioxidants, Nutrition science and bioactive compounds, New approaches to food analysis, Food allergens, Nutrition and immunology, Molecular biotechnology for the benefit of consumers, New functional foods, and Health effects of food.

The venue of the coference was at the Faculty of Chemistry, University of Belgrade, Studentski trg 16, Belgrade, Serbia. The deadline for abstract submission and travel grant application (open for young researchers and PhD students) was 29th of September. In total, 90 contributions have been received by the scientific committee and 28 travel grants have been granted to participants from 9 different countries. The main goals of Belgrade Food International Conference were to offer an inter-disciplinary arena of discussion and sharing opinions for scientists dealing with different aspects of food, as well as to create a novel scientific network. The scientific program included 20 lectures, 16 oral presentations and 57 poster presentations. In total, 120 participants from 17 countries attended the workshop representing 37 different institutions (25 institutions from abroad and 12 from Serbia). The highest number of foreign participants came from Romania, Germany, Greece, France and Tunisia.

After the final conference, a special issue of the Serbian Chemical Journal was printed based on peer-reviewed articles presented at the conference. The March issue of the *Journal of the Serbian Chemical Society* http://www.shd.org.rs/JSCS/ *(Issue Number 3, Volume 78)* contains selected articles from The Belgrade International Food Conference. Guest Editors of the Issue were Prof. Tanja Cirkovic Velickovic and Prof. Marija Gavrovic-Jankulovic, co-organizers of the International Conference. In total, 12 articles were selected for the publication, of which, 10 review articles and 2 original articles.

Experts of the EU-supporting institutions of the FCUB ERA project contributed to the special issue: dr Guro Gafvelin (Karolinska Institutet, Sweden), dr Arnd Petersen (Research Center Borstel, Germany), dr Theodore Sotiroudis (NRFH, Greece), dr Samir Naimov (PU, Bulgaria) and dr Estelle Bonnin (INRA, France). Review articles were also written by FCUB experts:

Dragana Stanic-Vucinic, Marija Gavrovic-Jankulovic, Tanja Cirkovic Velickovic, Milica Popovic, Luka Mihajlovic, Marija Stojadinovic and Milica Grozdanovic.

Scientific results of the project were disseminated at the international, regional and national level, at 41 conferences and meetings, increasing the FCUB contribution to regional economic and social sustainable development in the area of molecular biotechnology, food research, food safety and quality.

Promotion of the project and food science in general was achieved by starting-up a Food Interest Group within the Serbian Chemical Society (SCS), the oldest and the biggest scientific society in Serbia. The new Food Section was started-up in December 2010, earlier than planned in order to facilitate dissemination of the project. The SCS has more than 900 members and more than 20 subdivisions in other bigger cities in Serbia. That platform was also used as a forum for spreading the significance of food science, chemical research importance in achieving food quality and safety.

A brochure on the FCUB was published in the International Innovation magazine (December 2010, published by Research Media Ltd) and distributed over Europe and USA. A special conference for media was held in December 2012 in order to inform the research and public society in Serbia on the achievements of the project and possibilities the FCUB can offer to other research institutions and industry in Serbia, regarding collaborations, servicing and support in the field of food research, molecular biotechnology and proteomics (FCUB ERA press conference in ñMedija Centarò, Belgrade, 25th of December 2012). The press conference was announced on the web-site of the press centre (Medija centar, Belgrade) that has an online platform for wide dissemination of the conference announcements and facilities to disseminate online via web TV, the recorded event in full duration. Speakers at the conference were: Prof. Branimir Jovancicevic, Dean of the FCUB and member of the Advisory Board of the FCUB ERA project, Prof. Tanja Cirkovic Velickovic, FCUB ERA project coordinator, Prof. Zivoslav Tesic, group leader, Department of Analytical Chemistry, Prof. Miroslav Vrvic, group leader, Department of Biochemistry. Press conference in duration of 1h was broadcasted on the web-site of the press centre and on web TV: http://www.webtv.rs/drustvo/konferencije

Other dissemination activities in relation to promotion of the centre of excellence and recent developments in innovative food analysis methods resulted in articles published in Serbian magazine *Vecernje novosti* in March 2012 (http://www.novosti.rs/vesti/beograd.74.html:370200-Hemijski-fakultet-Najsavremenija-laboratorija-za-analizu-hrane), as well as in various daily newspapers, magazines and brochures. The Belgrade Food International conference was followed by Serbian state television (RTS 1) and a commentary was given for Serbian television by Professor Craig Faulds, INRA, France, a guest lecturer at the conference.

FCUB Food science groups had excellent collaboration with several Serbian companies before the start of the project. Traditional collaboration was related to brewery industry (applied enzymology and biotechnology).

Lecturs, seminars and presentations given at the FCUB for the purposes of know-how exchange with a wider auditorium. Intended participans in seminars were young reserchers, PhD students, MS students from the institutions, but also from other departments of the University of Belgrade.

Some of the talks, lectures , seminars and presentations organized by FCUB ERA project in order to disseminate results and widen the impact of the project:

10 May 2011, Luka Mihajlovic, FCUB : Cross-linking of peanut proteins by enzymes and peanut polyphenols characterization by mass spectrometry, STTM to VTT Institute of Biotechnology, Espoo, Finland

17 May 2011, Iva Perovic, guest lecturer from Brandeis University, USA: Solving protein structure by NMR ; Alpha-synuclein in Parkinson's disease

24 May 2011 Natalija Milcic-Matic, Faculty of Veterinary Medicine, Belgrade: Role of short ragweed pollen proteins in canine allergy, PhD project, FCUB and Faculty of Veterinary Medicine, Belgrade

31 May 2011, Jana Ognjenovic, FCUB: **Proteomics characterization of major linden pollen allergen, STTM to Research Center Borstel, Borstel, Germany**

07 June 2011, Dusan Velickovic, FCUB: **Transglycosylation reactions catalyzed by enzymes, FCUB**

21 June 2011, Marija Stojadinovic, FCUB: **Immunological reactivity of processed beta-lactoglobulin and Ole e 1-like protein of linden pollen , STSM to Karolinska Institute, Stockholm, Sweden**

Activation of dendritic cells by mugwort pollen proteins, STTM to Karolinska Institute, Stockholm, Sweden

28 June 2011, Danijela Apostolovic, FCUB: **Peanut allergens digestion in the presence of green tea catechins and oxidizes catechins, BSc project, FCUB**

09 July 2011, Milan Nikolic, FCUB: **Bioactive components of Spyrulina microalgae, STTM to NHRF, IBRB, Athens, Greece**

06 October 2011, Milica Grozdanovic, FCUB: Evolution of vector backbone towards higher expression of recombinant proteins**,** STTM to RWTH Institute of Biotechnology, Achen, Germany

14 November 2011, Maja Krstic, FCUB:**Mechanisms of cytotoxic actions of green tea, coffee and cocoa extracts, BS project, FCUB**

21 November 2011, Tanja Cirkovic Velickovic, FCUB: **Protein-polyphenols interactions of relevance in food and nutrition**

10 October 2011, Milica Grozdanović, FCUB: **Evolution of vector backbone towards higher expression of recombinant proteins**; STTM to RWTH Institute of Biotechnology, Achen, Germany

24 October 2011, Jana Ognjenović, FCUB: Improving properties of perhydrolases by epPCR; STTM to RWTH Institute of Biotechnology, Achen, Germany

31 October 2011, Milan Nikolić, FCUB : **Isolation and antioxidant activity of phycocyanobilin from *Spirulina sp.*;** STTM to NRHF Institute of Biology and Biotechnology, Athens, Greece

07 November 2011, Jelena Radosavljević, FCUB: **Codon optimization and cloning of Ara h 2 in *E. coli*, *P. pastoris* and *N. Benthamiana*;** STSM to PU, Plovdiv, Bulgaria

14 November 2011, Ivana Prodić, FCUB: **MR modifications of BLG under the influence of HI ultrasound;** MS thesis project, FCUB-ERA

21 November 2011, Maja Krstić, FCUB: Mechanisms of cytotoxic activity of green tea, coffee and cocoa extracts; BS project, FCUB

28 November 2011, Tanja Ćirković Veličković, FCUB: **Protein-polyphenols interactions of relevance in food and nutrition; STTM to UIC, Chicago, USA**

19 December 2011, Luka Mihajlović, FCUB: **Effects of *A. elatior* pollen phenolics on monocyte-derived dendritic cells; STMS to Karolinska Institutet, Stockholm, Sweden**

26 December 2011, Aleksandra Dimitrijević, FCUB: **Structural characterization of the reference xylo-gluco-oligosaccharides (XGOS) and galactoglucomanno-oligosaccharides (GGMOS) by ESI-Q-TOF and Orbitrap mass spectrometer; STTM to INRA, Nantes, France**; **Structural analysis of xyloglucans and galactoglucomannans from tomato by HPAEC and mass spectrometry; STSM to INRA, Nantes, France**

16 January 2012, Dragana Stanić, FCUB: **Report from Launch of the Innovation Serbia Project**

23 January 2012, Jelena Vesić, FCUB, **Purification and Characterization of Ovalbumin from hen egg-white and Catechins from teas, coffee and cocoa**
30 January 2012, Nenad Milosavić, FCUB, **One-step isolation and purification of Lipase A from *Candida antarctica***
15 april 2012 Dr Guro Gafvelin from the Karolinska Institute, Stockholm, Sweden ***"Immune regulation in allergic disease"***
6 February 2012, Marija Stojadinović, FCUB : Estimating native and cross-linked beta-lactoglobulin (BLG) sensitizing and tolarogenic potential in mouse model of BGL allergy and *in vitro* cell cultures; STSM to Utrecht University, Institute for Risk Assessment Sciences, the Netherlands
01 June 2012, Zora Markovic-Housley, PhD. "Identification of B-cell epitopes from the structures of alergen/antibody (IgE, IgG) complexes: implication of allergy treatment". Department of Structural Biology, University of Basel, Switzerland
08 June 2012, Milica Grozdanović, FCUB. "Construction of a Banana Lectin - Bet v 1a fusion protein". STTM to FZ Borstel, Germany
22 June 2011,Jana Ognjenović, FCUB. "Cross-reactivity between linden and olive pollen allergens". STSM to Departamento de Bioquimica, CSIC, Granada, Spain
27 June 2012, Hans Grönlund:New treatment options for allergies and asthma". Department of Medicine Solna, Karolinska Institutet, Sweden
28 June - 06 July 2012 : Sarah Thunberg, PhD. "Practical aspects of flow cytometry: Seminar and discussions". Karolinska University Hospital, Sweden
06 July 2012 Danijela Apostolović, FCUB. "Characterization of modified peanut allergens".
13 July 2012 Maja Krstić, FCUB "Methods for testing bioavailability of dietary minerals and proteins". COST Action FA1005 STSM to CRP Gabriel Lippmann, Luxemburg
13 July 2012, 12:00-14:00 Maja Krstić, FCUB "Methods for testing bioavailability of dietary minerals and proteins". COST Action FA1005 STSM to CRP Gabriel Lippmann, Luxemburg
19 November 2012, Luka Mihajlovic, *De novo* sequencing of proteins by mass spectrometry STSM to INTRA, France
26-28 November 2012, Horizons in Life Sciences, Practical training course,
8 April 2013: Jelena Radosavljevic: "Resistance of milk allergens IgE-binding peptides to pepsin digestion", STSM to Karolinska Institutet, Stockholm, Sweden
8 April 2013:Marija Stojadinovic: "Enzymatically polymerized beta-lactoglobulin: allergenicity and bioavailabililty in vivo", STSM to IRAS, Utrecht, Holland
8 April 2013: Milica Grozdanovic: "Influence of kiwi fruit protease on mucosal barrier in vivo", STSM to IRAS, Utrecht, Holland
16:15-16:30 Milica Grozdanovic: "Actinidin, a cystein protease from kiwifruit, disrupts tight junctions of epithelial cells", STSM to IRAS, Utrecht, Holland
18 March 2013"Vladimir Beskoski, "Characterization of environmental bacterial isolates using maldi-tof-ms – experience from the VTT"STSM to VTT, Finland
25 March 2013, Jelena Vesic, Development and validation of an MRM method of protein quantification by mass spectrometry STSM to INRA, France
29-30 March 2013, Ljubica Vojcic, RWTH, Germany
"Cloning in gram positive bacteria and yeasts – practical aspects"
"Dirigated evolution of proteins: methods and success stories".

Presentation of Results of the Serbian Honey Characterization with regard to botanical and geographical origin was presented at FCUB, in April 2011. Based upon agreement of cooperation

between FCUB, and The Centre for Food Quality Control, Belgrade, and The Association of Bee-keepers of Serbia, a comprehensive study of 380 honey samples of different botanical varieties from 13 regions of Serbia was conducted during 2010. Among the basic physic-chemical parameters, several characteristic chemical features were analyzed such as: amino acid composition, sugar profile, minerals and heavy metals, stable isotopes as well as fluorescent properties of honeys.

Realization of the research project was carried through the following institutions:

- University of Chemistry, Faculty of Chemistry,
- The Centre for Food Quality Control, Belgrade
- Institute for Veterinary Medicine of Serbia, Belgrade
- Institute for Nuclear Sciences ĂVinļañ, Belgrade
- SP Laboratory, Beļej

Prof. Ģivoslav Teğić and Prof. Dusanka Milojkovic-Opsenica organized the seminar and gave an overview of the work performed.

Several lectures and presentations were given by FCUB experts and invited experts from other institutions:

Kristina Lazarević, Centre for Food Quality Control, Belgrade: Is there a difference between Serbian honey and the honeys from the rest of the Balkan region?
The Association of Bee-keepers of Serbia: Physico-chemical parameters of honeys from Serbia
Milica Jovetić, Centre for Food Quality Control, Belgrade: Minerals and heavy metals in Honey
Jelena Keļkeğ, Institute for Veterinary Medicine of Serbia, Belgrade: What kind of amino acids are present in Serbian honey?
Filip Andrić, FCUB : Can you recognize a falsified honey sample based on its sugar profile?
Ivana Zeković, Institute for Nuclear Sciences ĂVinļañ, Belgrade: Is it possible to analyze a honey without opening a jar?
Zita Kelemen, SP Laboratory, Beļej: Is it possible to protect Serbian honey authenticity?

Since 2010, the most attractive collaborations for the enterprises were newly developed analytical platform for chemical analysis of food and proteomics technology.

Dissemination activities also led to the establishment of tighter contacts with local SME and industry:

- Involvement with wine producers. Contacts have been established with three largest companies in Serbia regarding collaboration on the improvement of product quality and geographic origin certification;
- Involvement with honey producers on further development of product quality and protection of geographical origin and authenticity determination (validation);

- Involvement with producers of organic/processed vegetables and fruits regarding evaluation of products quality and further development of new products based on processed foods;
- Involvement with Impamil d.o.o. on development of new products: infant formula and food for young children;
- Involvement with Institute of Immunology, Sera and Vaccine production, Torlak, towards improvement of allergenic extracts quality for diagnosis of food allergies;

Promotion of the Center for Food Science and Molecular Biotechnology resulted in an increased visibility of the institution and increase in the number of requests by enterprises to engage in further collaborative actions from the start of the project to today, enabling the FCUB to become a center recognized by its expertise and ability to answer the most challenging requests in the fields of food science and biotechnology.

Please provide a description of the potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and the exploitation of results. The length of this part cannot exceed 10 pages.

The main strategic impact of the FCUB ERA project was a significant reinforcement of the S&T potential of the FCUB by supporting and mobilizing their human and material resources:

FCUB ERA project reinforced and upgraded all currently existing facilities of the Center for Food Science and Molecular Biotechnology to a level of excellence similar to that of EU institutions. Already existing equipment is better employed with the 3upgrade. Major impact was on establishing the first operative proteomics centre in Serbia as an upgrade of the modest Protein Analysis facilities that existed at the FCUB. The proteomics centre is now able to service other research institutions working in the field of biotechnology, biochemistry and food chemistry, as well as life sciences in the country and the WB region. For successful implementation of the new equipment, appropriate training of the research staff was necessary, which was conducted in a form of several longer and shorter training visits of FCUB staff abroad, training and research visits of the incoming researchers from partner institutions and recruitment of the experienced researcher in support of facilities reinforcement.

A significant risk represented by the ñbrain-drainò of the trained researchers was targeted by several measures: obliged return mechanism of the trained staff and their obligation to train *in situ* several younger researchers to ensure a critical mass of the trained staff to perform the research on the acquired equipment. More than 50 lectures, seminars, presentations and workshops were organized within the FCUB ERA project in order to broaden the impact of the know-how exchange with the EU supporting institutions of the project. All training measures were open to wider auditorium and broadly announced via the web-page of the project, of the institution and poster announcements. Thereby, many young researchers from various other

academic institutions in the country benefited from the FCUB ERA project by participating in the dissemination activities of the project.

The FCUB ERA project enabled top quality experienced researchers to be recruited by the FCUB. National research projects are funded every fifth year, which means that researchers have to wait for several years to get employed by a national funded institution in Serbia, if the applying research team gets funding. Three experienced researchers were employed within the project and continued their contracts with the FCUB within the currently running nationally funded research projects and innovation projects, also as projects coordinators.

FCUB ERA project contributed to the raised level of training and education of already employed junior and senior research staff by enabling them to conduct research projects or get trained in outstanding EU institutions that supported the project. Several research visits were planned during the project with specific goals: bringing back the expertise in specified research fields related to this project: food bioprocessing (VTT), immunology and cell culturing techniques (KI), molecular biotechnology of allergens (KI), plant biotechnology (PPMB), immunotoxicology (IRAS), molecular biotechnology (RWTH), food quality and safety (IBRB), polysaccharides chemistry and enzymology of polysaccharides degrading enzymes (INRA), enzymology of oxidative enzymes and oil processing technology (IBRB). Several shorter research visits were also conducted in order to perform ongoing collaborative research projects or to enable junior researchers to get training for specific techniques, such as proteomics, real-time PCR, high-throughput research, gene-mining technology, Q-TOF MS, flow cytometry.

The FCUB is a higher education institution involved in education of chemists, biochemists, environmental chemists and chemistry teachersô at all three levels of education: BSc, MSc, PhD. The impact of broader education of junior and senior research staff of the FCUB was multiplied by their engagement in education of undergraduate and postgraduate students of FCUB. At the moment, there is in total more than 800 students involved at various levels of studies of chemistry and biochemistry.

The project involved recruitment of incoming experienced researchers; three senior researchers with expertise in the fields of food science and molecular biotechnology were recruited during the project duration. The recruitment of those experienced researchers was based on offering them high quality research opportunities, and a possibility to initiate their own research projects and supervise and co-supervise PhD students.

The project developed and fostered strategic partnerships with outstanding EU research institutions (VTT, KI, INRA, RCB, RWTH, NHRF, IRAS, PPMB) working actively in the field of food research and molecular biotechnology and having similar interests as FCUB;

The strong basis for fostering strategic partnerships with EU research institutions was already existing strong connections with partners in this project.
Significantly upgraded facilities of the FCUB are primarily used for research in the field of food quality, safety and molecular biotechnology for the benefit of society. The strong analytical platform that was established at the FCUB for both small molecules and bio(macro)molecules were made wide open for the society and industry in the country and the region of WB, in order

to support research projects of other collaborating institutions, but also to offer specialized analysis and development projects for the industry.

The results of the project were disseminated at the international, regional and national level, increasing the FCUB contribution to regional economic and social sustainable development in the area of molecular biotechnology, food research, food safety and quality;

Based on existing ongoing collaborative projects with partners involved, new possibilities for exchange of researchers, and high quality research as a consequence of upgraded facilities, more high quality publications were disseminated by the FCUB, thus raising its research reputation in Serbia, in the region of WB and worldwide. New research areas opened up throughout the course of the project, and especially via recruitment of new experts, were disseminated by web-portal of the project and by scientific publications and research conferences in the country and abroad. The impact of the project was also on the incorporation and exploitation of expertise of the FCUB in the biophysical and biochemical characterization of macromolecules, especially biomolecules, a research area that is not adequately developed in Serbia at present. Those achievements were disseminated by two planned workshops and a conference organized by the FCUB, also involving partners from the food industry. That expertise was missing in Serbia and building-in of new knowledge and expertise required participation of outstanding EU institutions and their active roles in helping FCUB develop in a sustainable manner.

The more efficient networking with other EU institutions besides those involved with the project was explored, especially through cooperation schemes, such as COST. These networking also resulted in the new collaborations of the FCUB.

Future research development

Newly implemented equipment is giving us a chance to develop our research toward emerging fields of proteomics and metabolomics, first of a kind in the country. With FCUB ERA project we have established laboratory for proteomics. Our plan is to further develop and upgrade proteomics facilities. We have successfully applied proteomics method in determination of food authenticity and safety, discovering of new allergenic proteins and new isoforms, modifications of food proteins and a broad range of other applications in food science and biotechnology.

Metabolomics is study of chemical processes involving metabolites and therefore of great importance for investigation of destiny of natural, as well as synthetic compounds in cell, tissue, organ and organism. We are working on the development of methods for toxicity assessment of potential drug candidates by metabolomics, and in that way eliminate a number of compounds before expensive clinical trials. As some of the groups from FCUB have projects working on synthesis of new drugs, they can test their compounds ``in house`` and in the future get funding for similar new projects. In perspective we also intend to deal with metabolomics of food additives and phytochemicals, and to pursue tracking of food and diet biomarkers.

Basic research in the food science

Basic research in food science is very important as applied research is directly relied on it. FCUB is known for high quality basic research, reflected in great number of publications in top

level journals. All benefits of FCUB ERA project are already visible in improvement of basic research, as can be judged from dramatic increase of number of published scientific papers, especially in journals with high impact factor and reputation in the field of food science. In addition, during the lifetime of the project there was increased number of new keywords in publications printed in scientific journals, including new subjects of research, diversification of research and new methods based on implementation of projectôs equipment. With FCUB ERA project we have got flywheel for highest level of basic science, and in front of us is definitely era of rapid scientific expansion toward becoming one of the most respectable institutions in Europe.

Applied research in the food science

We are planning to work on the development of new technologies which can be directly applied in the food industry, and in that way get funds for further scientific work, either through patent licensing or through direct investments by the industry. With our great knowledge in food science on molecular level we tend to be involved in creation of new functional food based on scientific research. Creation of food designed for special needs (for different age groups, for persons with different disorders and diseases) will be also challenge for us, and in that way we can help in increase of the life quality of a broad population. A good example of ongoing exploitation activities is the development of new prebiotic and probiotic products for healthy newborns - *In vitro* infant formulae and of nutraceuticals with organically bound trace elements. CFSMB experts extended and translated its research results to Serbian SME ñImpaz/Impamil LTDñ.

FCUB is already recognized by excellence in innovation at the national level. Two research teams of the CFSMB awarded First and Second Prize for the best technological innovation at the national competition for the best technological innovation in 2010. Competition involved more than 150 teams from all fields of technological innovation. Two technologies were presented: ñModified immobilized invertase in production of inverted sugarò, and ñ*In situ* bioremediation of polluted soilò. The CFSMB team also awarded the First Prize in innovation at the Nikola Tesla competition for the best product and best innovation in 2011.

Extensive analyses of small food molecules, phytochemicals (e.g. food fingerprinting), with the Structural Instrumental Analyses and Cell Culture Facilities, enabled and helped potential forming of Serbian Producer Association Body that would work closely with the Ministry of Agriculture on blockbuster fruit/diary product development for export to EU and other countries. This of course, wouldnôt have been possible, as well as branding process of Serbian honey, vine, cheese, fruits such as raspberry, if concrete and solid scientific data, about Serbian food products specifity, quality and authenticity, were not generated, presented and disseminated via FCUB ERA project.

In year 2012, CFSMB researchers awarded five top-ranked nationally funded research projects that in total brought nearl 1 000 000 EUR new equipment to the Faculty of Chemistry in a form of grants. Significant additional upgrade was achieved for laboratory for proteomics (pre-proteomics equipment for high resolution 2D PAGE and imaging), IR-MS (isotope ratio mass spectrometry), ICP-MS (for determination of trace amounts of minerals in food, soil and water), cell sorter and incubators (for enlargement of cell culture facilities) and state-of-the art spectrophotomer and microspectrophotomer for the upgrade of structural instrumental analysis

facilities. That way, full synergy of EU funding and national funding was achieved to round-up and upgrade facilities for food science and molecular biotechnology at the Faculty of Chemistry.

Reinforced Human potential

In the last two decades Serbia is well known as a country with high level of ``brain drain``. Open borders and low economic conditions further enhanced this process. Retention of experts is therefore of great national interest. FCUB-REA project enabled recruitment of experts and their integration in the research projects financed at the national level after the end of the project. For three senior recruited experts through the FCUB ERA project integration was achieved in the research projects financed at the national level after the end of the project.

Young researchers have also been trained and mobilized during FCUB ERA project. A direct benefit of mobilizing young researchers is related to strict requirements for their promotion into higher positions at the institution. The University of Belgrade, as well as Faculty of Chemistry is increasingly looking for staff that has been trained abroad and can bring new fields of research to the institution.

In line with this, FCUB ERA gave opportunity to young researchers to be trained at high reputation scientific institutions in EU. That way they brought in new knowledge and skills to FCUB and became able to establish new fields of research in the future. They will be promoted into higher positions in the coming years, and will be scientific stuff on which FCUB will rely on in next decades.

It is also expected that significant reinforcement of research infrastructure at the Faculty of Chemistry will attract and retain the country the best talents to work on research problems in food science and biotechnology at the level of research environment in EU countries.

Dissemination of the foreground

In general, future development and expansion of dissemination activities will help us to inform the scientific and general public on our potential and competence. Further dissemination of research excellence will involve maintenance of the web site of the CFSMB, active participation in media and through the Serbian Chemical Society.

Web site

The web-site of the project (www.fcub-era.rs) was started-up at the beginning of the project. The new Food Interest Group was formed within the Serbian Chemical Society in December 2010, thus allowing exchange of information and promotion of the food science within the largest network of chemistry professionals in the country. Improved visibility of the FCUB is reflected also from increased number of website hits. Being aware how powerful media is web-site, we will further broaden it, offering a much more detailed presentation of facilities at the FCUB, as well as research expertise of its staff and the servicing it can offer to community. We will be also more active in the education of the public through our web-pages. Web-portal will be regularly

updated, offering all information on ongoing activities, including seminars, workshops, lectures and trainings.

Active participation in media

From the beginning of the FP7 project there was the number of independent mentions in the media relative to the action. We will make an effort to be more present in all kinds of media. We also hope that media will be more interested for our work and success, as agro-food sector gains more attraction in the country. We are fully aware that, as an top-state educational institution, our obligation is also to educate the public through media.

Food interest group of the Serbian Chemical Society

Establishment of new section of Serbian Chemical Society, Molecular nutrition and food research interest group, already brought successful representation of food science and its perspective in Serbia. In the future, within this section we have planned more activities, such as section meetings and workshops, seminars, lectures, as well as an application for organization of the EuroFoodChem congress in 2017. Strong support for food science within the Serbian Chemical Society will be given by its newly elected President, Prof. Zivoslav Tesic, one of the Faculty of Chemistry experts in food science and leader of food analysis research group of the CFSMB.

Dissemination at scientific meetings

Scientific meetings are the most adequate opportunity for the scientist/researchers from different institutions/countries, dealing with different aspects of food science, to interchange opinions, share experiences and make collaborations. They are also the best way of representation of results of scientific work and progress, as well as institution itself. In the future, we are planning to increase attendance to scientific meetings, and to focus on meetings with specialized topics, which proved to be the most useful. To support this we will always have in mind to get or to allocate resources for this purpose, and to much more address the industry to support attendance.

New publications

During FCUB ERA project we published several chapters in the books printed by high reputation publishers, such as Springer. In this moment we are preparing a monograph that will be published by Springer: ñFood allergens: biochemistry and molecular biotechnologyò written by CFSMB experts Prof. Tanja Cirkovic Velickovic and Prof. Marija Gavrovic-Jankulovic. In the future we intend expend our publishing activity and collect our knowledge and experience into books, as we become increasingly recognized for our expertise in the field of food science and biotechnology at the international level. One of our aims is also to be, in near future, involved in writing of widely accepted university textbooks related to food science, and in that way contribute university education not only in Serbia, but in general.

Organization of dedicated workshops for research professionals in the field of food science

RegPot FCUB ERA project provided us opportunity to organize three international scientific meetings and get experience how to do it successfully, and in that way support our scientific reputation in the field of food science. We are planning to increase number of meetings we are organizing, and to give our best to provide the highest quality lectures and presentations. Our aim is to especially increase frequency of small workshop meetings, which are exceptionally beneficial. In contrast to big conferences, workshops do not need high financial support. Workshops with lot of discussions and round table, as well as with section dedicated to industry sector have shown to be especially fruitful, so our future workshops will include them. We also intend to stimulate our young researchers to attend meetings, as well as to provide grants for guest young researchers in order to support collaborations initiated by young scientist.

National recognition of excellence

In the near future, great financial investments are planned for agro-economical sector in Serbia. Serbia is increasingly recognized as prolific country for production of food, especially by countries with low food production and special needs. This direction of economical development of Serbia is in favor of development of FCUB toward food science. Therefore, accreditation of the Center for food science and molecular biotechnology is of great national interest, with aim to support Serbia to exploit its natural agro-potentials and become leader in food production/industry and biotechnology.

We are preparing an application for the Status of the National Centre of Excellence in Research. With a national label in research excellence, additional annual funding will be available in support of research excellence of the Centre. Successful results of FCUB ERA project, as well as overall progress in last few years, are more than convincing to show that FCUB is ready to be recognized for its excellence and to get Status of the National Centre of Excellence in Research. Strict requirements for the national status of excellence, such as high percentage of top-level scientists, number of highly-ranked publications in leading journals of the fields, international collaboration with academia and industry, success in organizing scientific meetings, conferences and advanced training schools have already been achieved as an important part of the FCUB ERA project. So far, in the Republic of Serbia, only four centers of research excellence have awarded this important national label. Successful results of FCUB ERA project, as well as overall progress in last few years, are more than convincing to show that FCUB is ready to be recognized for its excellence and to get Status of the National Centre of Excellence in Research.

Synergy with education

New courses in the syllabus of Chemistry and Biochemistry study programmes

FCUB-ERA project opened up an opportunity for FCUB to make synergy of with education. So far, within the ongoing accreditation period (2013-2017) to the syllabus for education of chemists, biochemists and environmental chemists, Center for Food Science and Molecular Biotechnology (CFSMB) of the Faculty of Chemistry contributed with several new elective courses in the field of food science and biotechnology: Food and Function (MS elective course), Food Biochemistry and Nutrition (BS elective course), Food Analysis (BS elective course), Environmental Biotechnology (MS elective course), Green Chemistry (MS elective course),

Molecular Allergology (MS elective course), Protein Engineering (MS elective course), Applied Catalysis (BS elective course). Programmes of the proposed new courses were drafted in 2012 and sent for evaluation to the University of Belgrade and Accreditation Committee of the Republic of Serbia. The University of Belgrade approved the proposed courses in April 2013 and the decision of the Accreditation Committee is expected to be reached in September 2013. Before 2013, no food science-related courses were offered to the students at the Faculty of Chemistry. Biochemistry students at the Faculty of Chemistry were only briefly introduced to the biotechnology subjects at BS and MS level.

New specialized study programmes in food chemistry and molecular biotechnology

A new initiative is taken by FCUB management to form a Committee in September 2013 that will draft new study programmes (specialized 2-year studies) in Food Science and Biotechnology for which CFSMB and FCUB ERA experts will be responsible. This measure will provide synergy between research excellence of the CFSMB and education, and provide food industry with highly qualified and well educated graduates in the future. It may be expected that new study programmes will be offered by the FCUB from October 2015.

More importantly, PhD students already enrolled at the Faculty of Chemistry, as well as young researchers from related disciplines will have full access to the Proteomics Core facility founded by FCUB ERA and training will be provided through the new course ñInstrumental Methods in Biochemistryò starting from year 2014. Young researchers will have access and gain training in mass spectrometry of proteins (proteomics) and small molecules characterization by high resolution MS/MS, CD spectrometry of proteins and small molecules, spectrofluorimetry and semi-preparative HPLC.

Synergy with education can be observed from the fact that during the project there has been an increase in the number of students writing a thesis on the topics connected with the project, as well as increase in the number of applications for PhDs in particular coming from students in the immediate region. FCUB is planning to further encourage students to do their PhD research in the field of food science and biotechnology by offering them state of art equipment, as well as experts to train them. We are aware that future of Serbian economy will be more and more focused on agriculture and food industry, and therefore, needs for experts in field of food science and biotechnology will constantly grow. From this moment FCUB has great potential to provide highly trained experts in this field, and thus be ready to actively become involved in Serbian economy. We hope that number of students will increase, as they can count on employment in agro-food sector and perspective future in Serbia.

Exploitation plan

FCUB Food science groups had excellent collaboration with several Serbian companies before the start of the project. Since the project beginning of the project, the most attractive collaborations for the enterprises were newly developed analytical platform for chemical analysis of food and proteomics technology. In the future our priority is to broaden our contacts with industry and intensify collaboration with SME. We can offer the servicing/consulting and in that

way raise our funds for research. During the project several memorandums of understanding for further collaboration with external private and public sector organizations were signed.

At this moment FCUB is not much experienced in patenting at international level. However, now, having few valuable inventions, we will work also on international patent applications. In the future patent licensing can bring us additional funds for research and CFSMB put it as a strategic goal to expend IPR and innovation management at the institution.

From the start of the project there is an increase in applications for participation in FP7 projects. Several FP projects proposals have been submitted, positively evaluated, but unfortunately not funded. FCUB ERA was for us driving force to be more active in project preparation. We also plan to do applications for Serbian Ministry of Science and Technology projects (call will be open in 2014) with support of EU institutions involved in this action. However, Serbian economy is still in very bad position, and funding for national projects will be extremely low, and far from enough for sustainability of research. Now, when we have got flywheel to do top science and have ambitious plans for the future, we are aware that we have to get additional finances from other funds. Therefore, our plan is to continuously increase effort put in writing new collaborative project proposals and to provide additional funding from collaboration with SME and industry. We also intend to increase joint applications with EU supporting institutions, such as ongoing application where FCUB is a VTT supporting partner with Finish Academy of Sciences and for WoodWisdom-Net Plus programme.

With new equipment implemented and know-how and skills gained through training and collaboration with the EU supporting institutions of the FCUB ERA project, FCUB has become able and competent to develop new methods for scientific, as well as for application uses. New methods will broaden exploitation of equipment and also will help to get financial support for its maintenance and upgrade.

Now, with highly sensitive equipment, we are going to develop methods for detection/and quantification of specific food contaminants, according to EU legislation. In order to protect human health EU legislation for food safety is now more stringent than ever, and with fast development of food industry, introduction of new foodstuffs and increase of frequency of food-related diseases, it will become even more rigorous. Therefore, we also intend to develop new methods for detection/quantification of food components for which food science have proved to be harmful to health, or in the other hand, have health-promoting effects, and which are not present in EU legislation at this moment. We intend to further implement mass-spectrometry based technology and methodology in the fields of bio-mass spectrometry, proteomics and bio-application of nanomaterials. One of our priority aims is to get accreditation of Laboratory for Food Authenticity. Serbia is famous for unique food products, as well as unique composition of widely used foodstuffs, due to optimal climate, soil and water. During FCUB-ERA project, it was started with the development of methods for investigation of food authenticity, such as honey products and wines. We are planning to broaden spectrum of methods for food authenticity and the food's spectrum as well. These steps will help Serbia to competitively offer branded foodstuffs with certificate of its authenticity and safety in the world-wide market. We also have in mind that counterfeiters are continuously trying to outwit authenticity law, so in the future more authenticity tests will be necessary to develop. Ministry of Agriculture has expressed

intention to financially support the Laboratory for Food Authenticity following accreditation of the FCUB for IR-MS method for determination of food geographical origin.

Important part of future activities of the CFSMB will be identifying and collaborating with potential users, as well as identifying potential partners and sources of finance for commercialization. So far, during the FCUB ERA project, involvement with important Serbian food industry and emerging SME in the food sector has been established. Contacts have been established with three largest wine producing companies in Serbia; involvement with honey producers on further development of product quality and protection of geographical origin and authenticity determination (validation); involvement with producers of organic/processed vegetables and fruits regarding evaluation of products quality and further development of new products based on processed foods; Involvement with Serbian wine producers on further development of product quality and geographic origin certification; involvement with Institute of Immunology, Sera and Vaccine production, Torlak, towards improvement of allergenic extracts quality for diagnosis of food allergies.

CFSMB also established important contacts with European SME and industry such as DBV Technologies (France), Hal Allergy (Holland), and Danone (R&D unit for Specialized Nutrition in Holland) regarding collaboration on improvement of food allergy diagnosis and therapy at the molecular level.

The FP7 equipment was implemented in 2011 and since 2012, requests to access new equipment have been made by several R&D engaged institutions from Serbia. Our wish is to offer access of our state of art equipment to all institutions from Serbia and stimulate collaboration with them for mutual benefit. For that purposes, a detailed description of technical specifications of the equipment, methods implemented by the CFSMB and contact persons for the equipment were described on the web-site of the project. We keep in mind that open access of all R&D institutions from Serbia and the region to all equipment purchased from EU financed projects will lead whole science in Serbia to the level of European science. CFSMB has already established itself as a problem-solving platform for R&D community in the country and the region of Western Balkans.

FCUB Food science groups had an excellent collaboration with several Serbian companies before the start of the project. Since the project beginning, the most attractive collaborations for the enterprises were newly developed analytical platform for chemical analysis of food and proteomics technology. In the future our priority is to broaden our contacts with industry and intensify collaboration with SME. CFSMB can offer servicing/consulting collaboration and in that way raise our funds for the research. During the project, several memorandums of understanding for further collaboration with external private and public sector organizations were signed. At this moment FCUB is not much experienced in patenting at international level. However, now, having few valuable inventions, we will work also on international patent applications. In the future patent licensing can bring us additional funds for a research and CFSMB with a strategic goal to expend IPR and innovation management at the institution.

It will be among the strategic goals in future to provide an efficient outlet to make the scientific community, industry actors and government aware of the activities and results of the CFSMB and to disseminate results of the R&D activities in the field of food science and biotechnology at the regional and international level. This will be accomplished through website of the CFSMB, organization of workshops and conferences dedicated to industry sector and SME as well as publication of e-news. The visibility of the Center will be ensured in addition to the interplay of lectures and discussions of scientists, young researchers and managers of the FCUB. Although this would lead to the wide awareness of society at large and the younger generation in particular, the dissemination plan of the FCUB widens its ambition to the measures which aim to ensure more engagement of industrial organizations and regional authorities in the exploitation of research results and know-how. The already existing connections of the FCUB research groups with the agro-food industry will facilitate the transfer of knowledge and exploitation of the results of the project, and will be the first line of action in order to convert the results of the project into economically and technically viable activities.

In years before 2010, public awareness in Serbia regarding the food quality and safety was very low. Nowadays, people in Serbia are aware that there are institutions such as FCUB, capable to give adequate and reliable scientific answers on food safety and quality. Still ñtriple-helixò of Government as a policy maker, Academia as a reliable scientific source of information and producers/importers of agricultural goods and products, has not made such a drastic progress in terms of harmonization and standardization of procedures, as the raise in public awareness of the importance of food safety and quality. Such dramatic raise in a public awareness and finally readiness of Serbian government to start to work and tackle public policies from this domain would not be possible without abundant and solid scientific data obtained from state-of-the art analytical platform developed and upgraded by the FCUB ERA project. One of the important outcomes in this domain is massive HACCAP implementation enabled via fine elements of analyses of the food quality.

The main impact of the project was the promotion of the top-level research at FCUB and strengthening of science and research at FCUB in a sustainable manner. Serbian society is aware that nowadays, in large owing to FCUB ERA project, there is national institution that can support food authentication processes. In a period before the project implementation, there was a mere public awareness about food health aspects mostly though its poisonous effects when contaminated, with the lack of distinction of food being itself source of allergy. Also there was no social conscience that food produced in Serbia, has some superb performances related to health, due to the favorable ratio of minerals, vitamins and other phytochemicals, again thanks to optimal combination of climate soil and water. Today, there is awareness that FCUB center is capable of distinguishing false from the original food (honey), determination of geographical origin (vine, honey, etc), which returns undermined trust to institutions responsible for food quality and safety testing. Before project implementation only some laboratories in EU, such one in Bremen, Germany, were capable and certified of undertaking such food analyses. Overall, society is fully aware of added value of Serbian food in regards to its superb quality, thanks to the optimal climate, soil, clean water. It is not difficult to predict that there is a great demand and need for such food internationally, and upon public policy harmonization on food quality, its export and economical benefits are almost guaranteed.

The development of chemical science in any country or region largely depends on the availability of investment in people and infrastructure. The Serbian governmentôs commitment of investing significant financial resources to improve the nationôs research arena and FCUB particularly has already begun to pay dividends. A number of scientific papers by FCUB scientists have appeared in highly reputable scientific journals of the fields and the number of students enrolling in the FCUB has been stable in the last two years, despite a Europe-wide declining interest in chemistry and other natural sciences. The proposed future developments outlined in FCUB ERA will serve to increase awareness of the importance of molecular biotechnology and food research to Serbia and the Western Balkan region as a whole. While the influx of new knowledge and personnel already provided an immediate short term advance, it will have a more profound impact forming the basis of the development of future food scientists in Serbia, who will benefit from the expertise of many of Europeôs foremost researchers in molecular biotechnology and food research.

THE PUBLIC WEBSITE ADDRESS AND RELEVANT CONTACT DETAILS

Web-site of the project: www.fcub-era.rs

Address of the institution:
University of Belgrade, Faculty of Chemistry
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Vice-Dean for Research of the University of Belgrade, Faculty of Chemistry: Prof. Maja Gruden-Pavlovic nauka@chem.bg.ac.rs

Supporting institutions of the FCUB ERA project:

INRA, Nantes, France (INRA)
Interest and expertise: Polysaccharides, Pectin, (arabino)xylans, Modification of polysaccharide structure and properties, Carbohydrate active enzymes.
Contact person: Dr. Estelle Bonnin, Group leader.

National Hellenic Research Foundation, Athens, Greece, (NHRF)
The Institute of Biological Research and Biotechnology, Athens, Greece (IBRB)
Interest and expertise: Isolation and purification of cellular membranes and subcellular organelles, Chemical modification of proteins, Protein phosphorylation, Protein kinases and phosphatases, Signal transduction, Lipid oxidation, oxidative enzyme activities, free radicals and antioxidants in plants and food (olive oil/olive fruit), Bioactive components of Microalgae.
Contact person: Dr. Theodore G. Sotiroudis, Research Director, Head of Enzymology Programme, Head of Industrial Enzymology Unit of IBRB.

VTT Technical Research Centre of Finland, Espoo, Finland (VTT)
Interest and expertise: Food (bio)processing, Discovering and characterizing new enzymes for food industry, Microbes as tools for tailoring product properties, Food aroma and flavour.
Contact person: Prof. Johanna Buchert, Research Director.

Karolinska Institutet, Stockholm, Sweden (KI)
Interest and expertise: Allergen characterization, Production and characterization of recombinant allergens. Regulatory T cells in allergic diseases. Allergen specific immunotherapy.
Contact person: Prof. Marianne van Hage, Head of the Department.

Research Centre Borstel, Borstel, Germany (RCB)
Interest and expertise: Food allergen characterization, Recombinant allergens production and purification, ESI-MS and structural instrumental analysis of proteins.
Contact person: dr Arnd Petersen, Group leader.

RWTH Aachen University, Institute of Biotechnology, Aachen, Germany (RWTH)
Interest and expertise: Protein engineering, Gene-mining technology, High throughput research, Discovering and designing new enzyme activities, Cloning in hosts other than E. coli, Patenting in molecular biotechnology.
Contact person: Prof. Ulrich Schwaneberg, Director of the Institute of Biotechnology.

Utrecht University, Institute for Risk Assessment Sciences, Utrecht, the Netherlands (IRAS)
Interest and expertise: Assessment of risks and benefits (to human, animal and ecosystem health) of exposure to new or biotechnological modified foods and/or food components.
Contact person: dr Joost Smit, Group leader.

University of Plovdiv, Department of Plant Physiology and Molecular Biology, Plovdiv, Bulgaria (PPMB)
Interest and expertise: Transgenic plants, Plant biotechnology, Molecular conformation and localization of membrane proteins, Molecular basis of plant stress response, Use of DNA markers in molecular taxonomy of parasitic plants.
Contact person: prof. Ivan Minkov, Head of the Department of PPMB, University of Plovdiv Vice Rector of Research.