



162nd CSO Meeting, 14 – 15 June 2005

Proposal for a new COST Action

**COST Action 928**

**“CONTROL AND EXPLOITATION OF ENZYMES FOR  
ADDED-VALUE FOOD PRODUCTS”**

**Proposer:**

**Dr. Johanna Buchert**  
VTT Biotechnology  
POB 1500  
FI-02044 VTT  
Finland  
[Johanna.Buchert@vtt.fi](mailto:Johanna.Buchert@vtt.fi)

**COST National Coordinator:**

**Eija Auranen**  
National Technology Agency  
TEKES  
POB 69  
FI-00101 HELSINKI  
Finland  
[Eija.Auranen@tekes.fi](mailto:Eija.Auranen@tekes.fi)

**Rapporteur:**

**To be appointed**

# **MEMORANDUM OF UNDERSTANDING**

**for the implementation of a European Concerted Research Action designated as**

**COST 928**

## **”CONTROL AND EXPLOITATION OF ENZYMES FOR ADDED-VALUE FOOD PRODUCTS”**

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/01 "Rules and Procedures for Implementing COST Actions", the contents of which the Signatories are fully aware of.
2. The main objective of the Action is to develop tailored bioprocessing technologies for especially cereal, berry, fruit and vegetable and proteinaceous (dairy, meat, fish) food raw materials in order to obtain higher quality food products.
3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at Euro 60 million in 2004 prices during the 4-year period of the Action.
4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.
5. The Memorandum of Understanding will remain in force for a period of four years, calculated from the date of first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

## COST 928

**”CONTROL AND EXPLOITATION OF ENZYMES FOR  
ADDED-VALUE FOOD PRODUCTS”**

## TECHNICAL ANNEX

**Abstract**

European food industry must continuously increase its competitiveness by implementing more advanced technologies for processing and creation of added value to the final products. Enzymes offer a sustainable, specific processing tool to food industry. Due to the specificity of enzymes, a variety of chemistries can be obtained by controlled action of these bio-tools in the food matrix. As a result of rapid development of biotechnological methods, novel enzymes and activity types can be isolated from nature for subsequent exploitation in different process stages. The full exploitation of these novel biotools in processing requires thorough understanding of the reaction mechanisms involved in both micro- and macroscale. The objective of the Action is to develop novel enzymes and tailored bioprocessing technologies for especially cereal, berry, fruit and vegetable and proteinaceous (dairy, meat, fish) food raw materials in order to obtain higher-quality food products. The objectives of the Action will be achieved by gathering the dispersed expertise within enzyme-aided food processing to a coherent Action.

**A. Background****A.1. State-of-the-art**

The food sector is an important sector in the EU and intrinsically affects the whole society. The food industry typically contains a large number of SMEs. Due to the strong competitive situation, European industry must continuously increase its competitiveness. Compared to many of its competitors, Europe is a high-cost production area. In order to maintain its competitiveness in relation to low-cost producing areas, it must develop and apply high level of technology. The competitiveness of European food industry will therefore depend on the implementation of more advanced technologies for processing and creation of added value to the final products. The biotechnology industry is also a significant industrial sector in the EU and Europe has been at the technological cutting edge in the development of sustainable biotechnological solutions for traditional industries. Biotechnology products are part of a global market; EU companies are world leaders in the production of industrial enzymes with a market share over 40%. Especially in the fields of food production and by-product valorisation the use of enzymes is expected to grow substantially. Enzymes offer a sustainable, specific processing tool, and reduce the amount of chemical additives needed in food processing. Natural food is one of the mega trends in consumer food expectations, and the amount of additives can remarkably be reduced by developing enzymatic solutions.

In addition to its nutritional value the food quality is related to its sensory properties i.e. **texture, flavour and colour**. Food is composed basically of biopolymers, which influence the mechanical properties, perceived texture, nutritional value and stability of fabricated foods. Flavour and colour are generally influenced by the lower molecular weight compounds present in the matrix. The chemistry of the biopolymers and lower molecular weight

components can be influenced by either added enzymes (**exogenous enzymes**) or the action of **endogenous enzymes** present in the food raw material. The action of endogenous enzymes may result in e.g. severe deterioration of vegetable quality due to enzyme-induced browning or tissue softening reactions. However, when properly activated some endogenous enzymes could also be beneficial for product quality. Exogenous enzymes are already used in several food processes, i.e. in fruit juice processing, cheese manufacture, baking and brewing. These processes are mainly based on hydrolytic enzymes. Nature, however, offers a wide variety of different enzyme types that could be exploited in food processing provided that their mode of action is understood and they can be efficiently isolated and produced for industrial use.

Due to the specificity of enzymes, a variety of chemistries can be obtained by controlled action of these bio-tools. Targeted modification of the food matrix by either added or endogenous enzymes influences, for example, intrinsic structure or flavour formation in foods. Furthermore, valuable products can be isolated from the current process by-products by using tailored enzyme technologies. Due to the rapid development of biotechnological methods, novel enzymes and activity types can be isolated from nature by traditional screening methods or by genome mining or engineered by e.g. in vitro evolution. By expressing these genes and/or by purifying the enzymes, the mechanistic and application perspectives of the novel enzymes can be further explored. The full exploitation of the novel biotools in processing requires thorough understanding of the reaction mechanisms involved in both micro- and macroscale. Thus, expertise in protein chemistry, food chemistry, in polymer science and food processing has to be combined. This also involves a variety of advanced analytical techniques to be developed.

Food raw materials also contain proteinaceous inhibitors to major glycosidases used in food processes. Their presence as natural components in e.g. plants can affect the utilisation of exogenous enzymes in food processes. Minimising the effect of these inhibitors would allow the use of lower (and thus more economic) doses of enzyme preparations. On the other hand these inhibitors could be used as a new biotechnological tool in order to monitor and/or trigger the specificity of these enzymes. Thus, when studying enzyme machinery in food matrix, it is necessary to investigate concomitantly the presence and the role of proteinaceous inhibitors.

During the last ten years many project related to food bioprocessing have been carried out in the EU and, consequently, a lot of knowledge has been generated within Europe. The knowledge obtained in these projects is, however, dispersed and thus relatively limited number of industrial processes has been established. The industrial exploitation of bioprocesses is expected to increase if the scientific knowledge generated in these different separate projects is put together via efficient collaboration and networking. As a result added-value food products can be produced by the food industry to the benefit of the consumers. Furthermore, by developing more sustainable, low-energy processes the competitiveness of the food industry can be increased. Sustainable food processes also have positive effects on the environment as less waste is generated. Ongoing and completed national and EU-funded projects related to the Action can be divided into two groups, i.e. predominantly biochemical projects in which microbiology, genetic engineering and protein chemistry are the key scientific disciplines. The other group consist of process technology-oriented projects with experts in food and process technology. The key challenge is to get improved knowledge and know-how sharing between these two groups and by that way get the dispersed knowledge benefiting different disciplines.

Basic enzymology of carbohydrate degrading enzymes has been studied in several EU projects. Wageningen University has focused on pectinolytic enzymes and other *Aspergillus* derived hemicellulases, whereas IFR has more worked on esterases. Biochemistry and mode of action of hemicellulotic enzymes has been investigated especially in Slovakia. Cross-linking enzymes are investigated within CROSSENZ –EU-project by experts from Finland, France, Ireland and Denmark. The enzymology of endogenous enzymes and proteins and their kinetics during processing especially cereal and vegetable raw materials is being elucidated by KU Leuven and others. The effect of enzyme inhibitors in cereals has been investigated in GEMINI –project as xylanases used in industrial applications are significantly affected by the inhibitors naturally present in cereals.

Enzymatic process applications have been mainly developed using existing commercial enzymes. In addition a significant activity has focused on development of novel process technologies such as high pressure etc. by e.g. TU Berlin and KU Leuven and others. Berry processing with existing commercial enzyme mixtures has been optimised in national projects in e.g. Denmark and Finland. Norwegian and Icelandic researchers have concentrated on proteinaceous raw materials and their modification. Starting EU-projects will deal with food process valorisation (REPRO) and in also this context novel enzyme-aided processes and knowledge on the chemistry and macromolecular properties of the raw materials is of utmost importance.

As a summary, many activities in the field are dispersed and subsequently limited number of industrial processes has been implemented. Thus, coherent networking is needed to transfer knowledge between the groups working in basic enzymology and those more concentrating on application development. This is highly justified as from the chemical point of view the food raw materials contain proteins, lipids and carbohydrates as main components and generic knowledge can be utilised when enzymatic processes are developed. The Action will especially focus on creating collaboration and networking with COST Actions relevant to the area, i.e. COST Actions 921, 926 and D25. Furthermore, attempts to efficiently interlink ongoing EU-funded projects (e.g. CROSSENZ, MAXFUN, REPRO, HEALTH GRAIN etc) and relevant national projects to the Action will be carried out.

## **A.2. Need for a COST Action**

Several research groups in Europe are engaged in the areas related to the Action, but the information and knowledge obtained is dispersed. Thus, there is huge need for combining all the efforts in the area. Coordination of ongoing activities will improve the competitiveness of the food enzyme industry as well as the food production industry as compared to USA and Japan. The COST Action offers the best framework for such cooperation. The industrial relevance of the Action is reflected by the broad interest of companies shown to the Action already during the planning phase.

The food industry is constantly seeking for novel products being more adapted to consumer needs. In addition to large global food companies, the EU has a significant number of the industrial players, which are SMEs. Bioprocessing, due to its low investment costs, offers means to both industrial sectors. Thus, opportunities for tailored bioprocesses are enormous as with these processes novel functionalities can be generated to the product without any need for chemical addition. The COST Action is focused on understanding and exploiting novel microbial and plant enzymes on food components, using model substrates and advanced

analytical techniques. Furthermore the control and activation of endogenous enzymes will be investigated and compared to the mode of action of exogenous enzymes in food matrix. Finally, novel processing stages will be developed, taking into account the chemistry and macromolecular structure of the target food matrix and feeding this information back to enzyme development.

### **B. Objectives and benefits**

#### **B1. Objectives**

The main objective of the Action is to develop tailored bioprocessing technologies for especially cereal, berry, fruit and vegetable and proteinaceous (dairy, meat, fish) food raw materials in order to obtain higher-quality food products. During the Action novel enzyme tools for modification of food biopolymers will be developed. These tools will be further exploited to engineer the quality characteristics of foods, i.e. structure, color and flavour. In the bioprocesses both exogenous enzymes and tailored methods to activate or control the endogenous enzyme machinery of the food matrix will be used. The objectives of the Action will be achieved by gathering the dispersed expertise within enzyme-aided food processing to a coherent Action.

The secondary objectives of the Action are the following:

- To increase basic knowledge on the mode of action of hydrolytic and non-hydrolytic enzymes in food matrices using advanced analytical techniques and model substrates as tools.
- To develop and understand means to systematically control the activity of exogenous and endogenous enzymes during processing
- To develop targeted methods for boosting or inhibiting endogenous enzymes present in the food raw materials
- To develop novel bioprocesses for the berry, vegetable, fruit meat, fish, dairy and cereal industry to improve the functionality and quality of the products

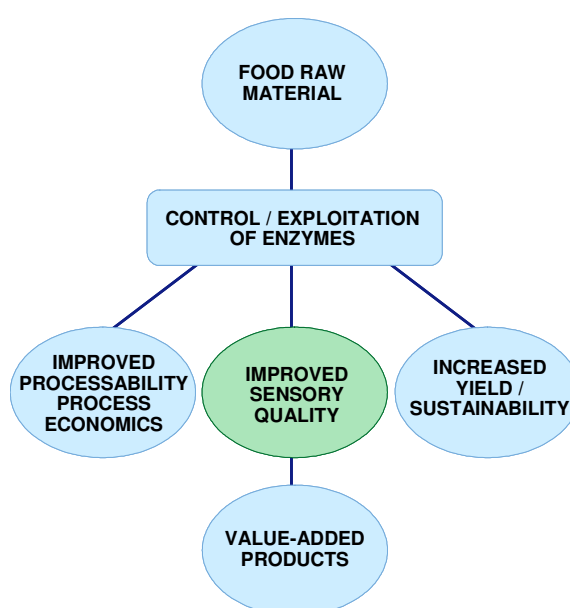
The objectives will be achieved by efficient knowledge-transfer between the participating groups. There will be special emphasis on increased mobility of scientists between groups and on knowledge transfer to less-favoured regions.

#### **B2. Benefits**

The scientific outcome of the Action will contribute to the development of new enzymatic processes for the food industry and will also give feedback to the enzyme industry on needs for novel enzyme activities in that sector. The Action will help SMEs with limited research facilities in developing and adapting bioprocesses. Adapting new technologies is important for the competitiveness of the sector with respect to e.g. USA and Japan. The Action will also benefit the agricultural sector as value added products can be generated from their raw materials.

The Action combines high-level scientific disciplines to a coherent Action, *i.e.* biochemistry and enzymology are combined with food chemistry, polymer science and process technology. Development of new and better controlled bioprocesses will permit production of added-value food products with improved consumer appeal as reflected by improved texture,

flavour or colour as outlined in Fig. 1. As co-benefit, the processability and sustainability of the production can improve. The benefits described will be achieved by exchanging research information within European research units active in enzyme discovery, enzyme catalysis, molecular biology, food chemistry and technology. The COST Action will search for novel enzymes and novel enzymatic processes for the modification of food biopolymers or components and enzyme action will be investigated using advanced analytical techniques. During the Action know-how about enzymatic processes and control of endogenous enzymes in food matrix is delivered to the participants and European food companies through annual workshops and publications. Potential needs for food enzymes will also be transferred to experts on enzymology which should lead to development of novel enzyme tools for the food industry. Thus, as the COST Action provides exchange of information between research institutes specialised either in biotechnology or food processing the entire area of food enzymology will be improved.

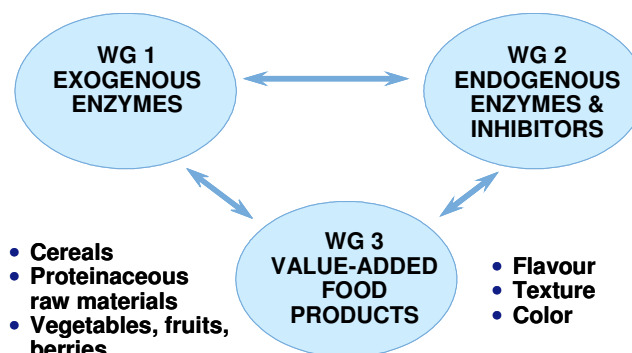


*Figure 1. Benefits of food bioprocesses.*

### **C. Scientific programme**

Research within food enzymology is very broad and involves areas such as enzymology, genetics, chemistry, analytic chemistry, rheology, material science and process technology. The food matrix is basically composed of proteins, lipids and carbohydrates. Enzymes can tailor the chemistry of each component selectively. Depending of the enzyme type different types of conversions can be obtained, i.e. polymer cleavage, selective removal of component from a macromolecule, cross-linking, oxidation etc. The end result does not only depend on the enzyme(s) used but also on the macromolecular properties of the food matrix. The food matrix also contains endogenous enzymes which may affect the final product quality. Furthermore, different types of inhibitors present in the food matrix may influence added enzymes.

The COST Action covers three areas as presented below. Each topic will be covered in a Working Group. The outline of the interaction between the WGs is presented in Figure 2.



*Figure 2. Structure and interaction of the WGs in the Action.*

Expected overall deliverables of the COST Action are listed below. In addition, specific deliverables for each WG are described in the WG description.

Deliverables of the whole COST Action:

- i) establishment of viable 'think tanks' within each of the Working Groups with sufficient multidisciplinary competence, thus ensuring the innovativeness for the industrial partners,
- ii) ensure exchange of necessary scientific competence between partners using Short Term Scientific Missions,
- iii) establishment of a food bioprocessing related platform, which can apply for future EU funding

WG 1. Development and mode of action of novel biotools (EXOGENOUS ENZYMES)

*The objective of this WG is to develop novel exogenous enzyme tools from microbial or plant sources and investigate their mode of action using model substrates.*

The work is focused on basic enzymology of novel microbial enzymes being able to affect the quality, i.e. texture, flavour and colour of food. The research will focus on hydrolytic, cross-linking and functionalising enzymes, which are all potential tools for tailoring a variety of important properties of food products. The type of enzymes required will depend on the nature and composition of the target food materials used in WG 3. Novel enzymes being able to catalyse the target reaction will be screened from the natural diversity or alternatively screened using genome mining. One parameter in the screening will be the process applicability and substrate specificity of the enzymes. In some processes it is desirable to have very thermophilic enzymes whereas in some other processes more cold-adapted enzymes are needed. In certain cases protein engineering will be used in parallel to develop enzymes with the required specificities. The enzymes of interest will be produced at a large scale after cloning and overexpression in homologous or heterologous hosts.

In order to be able to develop targeted enzyme-based processes, a thorough understanding of the mode of action and reaction kinetics of the most relevant enzymes is needed. For this purpose, advanced analytical techniques, such as HPLC-MS, GC, SEC, EPR and NMR etc.

will be used. For protein fractions, modern MS-based tools in proteomics will be used, as well as relevant information from post-genomic databases. Factors affecting the performance of enzymes in the food matrix (accessibility, inhibition, substrate interaction, temperature, pH, ionic strength) will be examined using model materials and these results will be transferred to actual (more complex) food matrices in WG 3.

The suitability of crosslinking enzymes to create novel types of structures in isolated proteins or carbohydrate polymers will be investigated in WG 1 and exploited for structure engineering purposes in WG 3. The textural properties of a single protein can be tailored by cross-linking enzymes in different ways: 1) By introducing different types of covalent bonds (e.g. tyr-tyr, tyr-cys, tyr-lys, gln-lys and cys-cys) between amino acid residues during or after processing and 2) by changing the kinetics of cross-linking. Carbohydrates can be crosslinked via their ferulic-acid moieties.

Hydrolytic (glycosidases, peptidases, proteinases) and oxidative enzymes, which are able to modify the chemistry of lower molecular weight components affecting the flavour or colour characteristics, will also be investigated using model compounds.

Expected deliverables:

- Novel hydrolytic enzymes (glycosidases, proteases, peptidases) being able to alter the flavour characteristics of food raw materials
- Novel crosslinking enzymes (oxidative and transferase type enzymes) affecting the rheology of food biopolymers
- Understanding the mode of action of the enzymes on simple and complex substrates
- Understanding the mechanisms involved in synergistic enzyme activities

### WG 2. Tailoring and control of the endogenous enzyme machinery in food matrix (ENDOGENOUS ENZYMES)

*The objective is to develop methods for tailored activation or inhibition of the endogenous enzymes present in the food matrix. The objective is also to understand the chemistry of endogenous enzyme inhibitors present in the raw materials and their role in enzyme catalysis.*

Food raw materials contain a wide variety of endogenous enzymes being able to affect the sensory properties of the products positively or negatively. Endogenous hydrolytic enzymes play a major role in flavour and texture characteristics and stability during food processing. Lipases are responsible for lipid degradation and their control is a key point in flavour stability and shelf-life of many food products. However, lipolytic enzymes can offer a novel tool to produce new flavour precursors and compounds affecting the mouth-feel of the products. Due to the action of proteolytic enzymes a variety of peptides are formed. These peptides strongly contribute the flavour of the food products but also are involved in the formation of food structures, and flavour and colour compounds through i.e. Maillard reaction. Carbohydrate degrading enzymes are dominating factors in several flavour and structure related properties of food products. Thus a better control of the action of endogenous carbohydrate degrading enzymes would increase the stability of various types of foods.

Oxidative enzymes are well-known for their deteriorating properties but can also be essential for food structure, colour and flavour. The action of lipoxygenase can be drastic for flavour and flavour stability but its role in structure formation in baking and bleaching of flour is well-known. Polyphenol oxidase causes the browning reactions in vegetables and thus targeted sustainable methods to inhibit this enzyme are currently being examined. However, in certain applications this browning could also be exploited for the benefit of the sensory quality of the products. Furthermore, many plants contain cell wall-bound peroxidases which can cause crosslinking of the food biopolymers and which may also influence exogenous cross-linking enzyme activities. The effect of endogenous enzymes on food products is complex and the effect of homologue enzymes may differ significantly between products. For example the peptidases responsible for the tenderisation of meat cause tissue softening and thus loss of prime quality in seafood products. In addition, the role of endogenous inhibitors is not well characterised in many food systems and their utilisation in the control of enzymatic reactions during food processing is minor.

Proteomic tools and database mining will be employed to look at the types and changes in the levels of endogenous enzyme types present during different stages of processing. Lipidomics will be used to study the action and control of lipolytic and lipid oxidising enzymes in food systems. The chemistry and physiological role of endogenous proteinaceous inhibitors will also be examined and where possible, new inhibitors identified and characterised. Other regulating factors, such as temperature, pH, pressure etc, to control the activation of activities during processing will be investigated.

Changes in temperature, pH, ionic strength, encapsulation, etc and the molecular basis of inhibitor interactions will be investigated as a means to regulate the activation of endogenous and exogenous enzyme activities during processing. The inhibitors will be used to achieve a better control of the enzymatic reaction and to selectively target enzymes within a commercial microbial enzyme preparation.

Expected deliverables:

- Prevention of action of endogenous enzymes negatively affecting food quality
- Activation of beneficial endogenous enzymes to improve processability, flavour and texture
- Understanding of the role of proteinaceous inhibitors on the action of microbial and endogenous enzymes
- Investigating the effect of selective binding of inhibitors on simple and complex substrates

### WG 3. Improved food quality via bioprocessing (BIOPROCESSING)

*The objective is to exploit the developed biotools for manufacture of food products with improved quality, i.e. flavour, texture or colour. The objective is also to improve the raw material utilisation and decrease the need for added chemical ingredients in the processes by tailored bioprocesses and by-product valorisation.*

The suitability of the developed biotools obtained from WGs 1-2 to improve the sensory properties of cereal, vegetable, fruit, dairy and meat/fish products will be investigated. The raw materials will be treated with different enzymes using different treatment regimes and the

impact on chemical, rheological and sensory parameters will be analysed. Simultaneously, analytical methods will be developed. The possibility of both oxidative and transferase type cross-linking enzymes to create novel textures to proteins and arabinoxylans will be investigated in baking, dairy and meat matrices. The impact of reaction kinetics and processing conditions on the formation of inter- or intrapolymer crosslinks will be investigated. Another approach to tailor food matrix texture is to inhibit certain endogenous enzymes being responsible for softening of the tissues. This can be achieved by e.g. using pectinmethylesterase inhibitor (PMEI). It has been suggested that PMEI could be successfully used to control PME activity in fruit and vegetable juices over long storage periods thus enabling storage of frozen products at higher temperatures.

Enzyme-aided new processes to isolate dietary fibre components specifically composed of desired polysaccharides of high functionality as food ingredient will also be investigated. The targets are to characterise the enzyme solubilisation of fibre components in cereal endosperm, to clarify the correlation between structure and functionality of the fibre components and to control the structural composition of the fibres based on a controlled enzyme hydrolysis. For example, the plant cell wall carbohydrates  $\beta$ -glucan and arabinoxylan are of major importance as fat substitutes used for texturising. Since they also can be used to create water solutions of high viscosity, these carbohydrates are very useful in food systems, especially after tailored modification. Their functionality is highly dependent on their molecular structure and molecular weight, and, especially for arabinoxylan, also the degree of substitution.

Xylanases are important enzymes involved in cell wall breakdown in cereals and as such are utilised in many cereal-based processes as additive for bread making, aiding in separation of wheat or other cereal gluten from starch, extracting more fermentable sugar from barley for making beer, etc. However the extensive breakdown of arabinoxylan during cereal-processing may be counterproductive to human interests by lowering the level of beneficial compounds. Many plant foods also contain endogenous inhibitors of xylanases which could be used as a new biotechnological tool to trigger/modulate the specificity of these enzymes for a better control of the balance between high molecular weight dietary fibers and low molecular weight prebiotics.

Flavour boosting will be investigated using mainly hydrolytic enzymes being able to modify the chemistry of flavour precursors. The impact of processing (thermal etc.) on the reactivity of the flavour precursors will be investigated. Special emphasis will be on proteinaceous raw materials, i.e. meat, fish and dairy products, and also on cereals, especially rye. Possibilities to remove the outer dead tissues of cereal grains by special enzymes such as, ferulic acid esterase, coumaroyl esterase, xylanases and arabinosidases will be studied as will be the effects of this removal on texture and flavour.

Hydrolytic enzymes are currently used in fruit industry to facilitate processability. Enzymes have traditionally been used for clarification of juice. In addition, enzymes have been used to degrade either the pectin network of the cell wall (maceration) or to break down the entire cell wall matrix to enhance the fruit juice yield even further (liquefaction). Some side activities present in the enzyme mixtures may adversely affect of stability of phenolic compounds, thus negatively affecting the product colour. Thus by tailoring the enzyme mixture used in fruit or vegetable processing the colour of the product can be improved. The novel enzyme processes may be a base for redesigning the enzymatic processing steps in fruit and vegetable processes and hence hold perspectives for development of more gentle

processing methods and of products of higher quality with respect to colour, flavour, and content of potentially health promoting substances

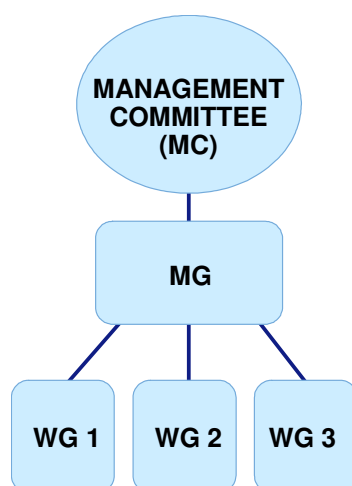
Also enzyme-aided fractionation of natural colors and hydrocolloids from process co-products will be investigated. Cereals, proteins, fruits and vegetables constitute a large part of food processing residues. These by-products contain large amounts of nutrients, micronutrients, rheologically important polymers, flavours, colourants (juices) and residual proteins and essential oils. The enzymes developed in WG 1 will also be exploited for isolation of novel food ingredients from these by-products. Novel enzyme-aided technologies for the tailored pre-treatment of fruit and vegetable raw materials will thus be developed in order to enhance the isolation hydrocolloids (e.g. pectin or proteins) or functional low MW components (colorants, hydrolysates) from the process by-products. These novel enzyme processes may be a base for redesigning the enzymatic processing steps in fruit and vegetable processes and hence holds perspective for development of more gentle processing methods and of products of higher quality with respect to colour, and flavour. An understanding of the composition and structure will allow the development and controlled utilisation of more precise enzyme processing aids for the recovery of natural food ingredients from current process by-products.

Expected deliverables:

- Novel enzymatic structure engineering concepts for dairy, meat, fish and baking applications
- Novel methods to boost food flavour or colour
- Novel fruit, berry and vegetable bioprocessing concepts
- Enzyme-aided cereal processing methods
- New enzyme-aided processes for by-product valorisation

### **D. Organisation**

The management of the Action will be accomplished by the **Management Committee (MC)**. The practical management of daily issues is carried out by the **management group (MG)** involving the MC chairperson and the WG leaders. In addition, a person responsible for Short Term Scientific Missions (STSM) will be selected in the kick-off meeting. This person will also participate in the MG. MG will predominantly communicate via e-mail in between the MC meetings. The MC will meet at least once a year to review the progress and to make strategic planning of the Action. Coordination and overseeing the activities in the different areas and their interactions will be the responsibility of the MC. The Organisational structure of the COST Action is presented in Figure 3.



*Figure 3. Organisational structure of the COST Action*

The Action is divided into three interactive **Working Groups** (WG) with short names in parenthesis (Figure 3). **WG leaders** will be selected at the kick-off meeting among the most eminent scientists in the field. The WG leader will be responsible for coordinating activities and ensuring that the WG will meet the targets defined in the work plan. The work of the WGs will include ensuring the scientific outcome of the WG, organisation of relevant sessions during the Annual workshops, and the organisation of WG meetings or smaller meetings with a selected group of experts. The structure of the Action is flexible and if needed additional WGs covering important issues relevant to the Action may be considered later.

WG 1: Development and mode of action of novel biotools (EXOGENOUS ENZYMES)

WG 2: Tailoring and control of the endogenous enzyme machinery in food matrix (ENDOGENOUS ENZYMES)

WG 3: Improved food quality via bioprocessing (BIOPROCESSING)

**Interactive WG meetings** are an essential part of the Action and will be held once or twice per year. In order to maximise interaction, the WG meetings will be preferably organised as joint-meetings with at least two WGs combined in the same meeting. During the course of the action the WGs participating together will be alternated in order to get maximum interaction (see Table 1). **The Annual Workshop** will be a forum to discuss and share the latest developments in the area with industrial participants and additional invited speakers. If appropriate, also **Inter-COST workshops** with related Actions will be organised with special focus on interactions with COST Actions 921, 926 and D25. Joint seminars with running EU-projects related to the Action (CROSSENZ, MAXFUN, REPRO, HEALTH GRAIN etc) will also be organised when applicable.

**E. Timetable**

The duration of the Action is 4 years. The 4 year duration is justified due to the ambitious nature of the tasks and long-term objectives involved. Activities related to WG 1 are rather time-consuming as novel enzymes are screened from natural diversity, produced and characterized. The production of these enzymes in larger quantities requires also time and thus application development with these novel enzymes can be started after about 1-2 year period. The participating institutes have, however, experimental enzyme preparations already in their hands and thus activities using these enzymes can start already during year 1.

The following activities will be organized during the course of the Action (Table 1). The **Kick-off meeting** will start the Action and during the kick-off meeting the WG leaders will be selected. **WG meetings** are an essential part of the Action and will be held once or twice per year. The **Annual Workshop** will be a forum to discuss and share the latest developments with industrial companies and scientists in the area.

*Table 1. Timetable of the Action.*

	Year 1	Year 2	Year 3	Year 4
Kick-off meeting	■			
WG meetings*	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■
MC meetings	■ ■	■ ■	■ ■	■ ■
Annual workshop		■	■	■
Final workshop				■ ■
Reporting		■	■	■ ■
Final evaluation				■ ■

\* Meetings will be organised simultaneously with alternating combinations of two WGs at the time, i.e. a joint-meeting with WG1+WG2, WG1+WG3, WG2+WG3 etc.

**F. Economic dimension**

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: FI, DK, UK, FR, NO, NL, TR, IS, DE, BE, IT, SK. Thus, in the planning phase 12 countries and 19 institutes/ universities have been actively involved. It is, however, expected that the number of participants will increase substantially during the course of the Action.

On the basis of national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2004 prices, at roughly 60 million Euro in the 4 year duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the economic dimension accordingly.

**G. Dissemination plan**

The COST Action outcome is planned to be disseminated as follows (Table 2). The primary dissemination tool between the partners will be the **WG meetings, annual workshops** and the **website** which will have a public part and a restricted part for partners only. The restricted website will contain all the minutes and reimbursement lists, whereas the public site will contain newsletters, information of WG activities and general information on coming meetings.

Scientific and technical knowledge coming out of the COST Action will be presented in **International Conferences** in order to promote the European know-how and expertise in the area. The major annual event of the Action will be the **Annual Workshop**, in which also key international experts in the field will be invited as speakers, when appropriate. Original research results obtained will be published in **international peer-reviewed journals** as joint papers between the participating universities or institutes. Special emphasis will be put on encouragement of paper submission by the partners taking part in an STSM.

The **public awareness** of the benefits and possibilities of bioprocessing in food technology will also be addressed in order to increase the public acceptance of the developed technologies. This will be achieved by dedicated newsletters and contacts to policy makers and stakeholders.

During the Action novel biotools and bioprocesses are developed for the food industry. As the practical research is funded by both national and EU-funded projects the resulting intellectual property rights are owned by the respective projects. However, if novel inventions arise from the collaboration the IPR issues will be discussed separately and specific agreements will be made.

*Table 2. Dissemination of the COST Action outcome*

<b>Method of dissemination</b>	<b>Main target groups</b>	<b>Quantity</b>
Brochure	Industry, academia, public	1
Collaborative scientific papers	Academia	Several
Workshops	Participants, others	5
WG meetings	Partners	several
Scientific conferences	Academia	Several
newsletters	Industry, academia, public	1–2 /WG
www-page	Industry, academia, public	1
www-page restricted	Partners	1

**COST 928**

**”Control and exploitation of enzymes for added-value food products”**

**ADDITIONAL INFORMATION  
NOT PART OF THE MoU**

**Additional Information**

## **H. History of the Action**

Idea for this Action arose during several EU-project meetings relevant to food bioprocessing during the years 2002-2004. The need to put the dispersed activities on food enzymology together to a joined Action was clearly understood. It was also realised that scientists from different disciplines, i.e. enzymology, food chemistry and food technology need a joint forum to create added-value to the innovations in food sector. Further, the research on biotechnology had been very rapid during the last decade and it was realised that these activities and know-how should also benefit the food sector. It was also known from a successful COST Action (e.g. COST 847) that is a good asset for networking. Although covered totally different topic as compared to the current application, it had shown the unique possibilities of COST networking to the scientists. The discussion on the proposed new Action started with experts especially from FI, UK, NL, DK, FR and N. After the decision to apply for a COST Action was made during autumn 2004 several potential partners were contacted and they were actively involved in the writing phase.

## **I. Preliminary work programme**

The framework of the Action will be presented to national delegates in the first MC meeting. The main item of the first MC meeting is to elect a chair, vice-chair and WG leaders of the Action. Also a person responsible for STSMs will be selected. The first discussions will be on a meeting timetable and brainstorming on the meeting topics will be carried out. Meetings will be organised simultaneously with alternating combinations of two WGs at the time, i.e. a joint-meeting with WG1+WG2, WG1+WG3, WG2+WG3 etc. After the discussion the venues and organisers of the first year meetings will be decided. Finally the tentative date, venue and organisers of the first annual workshop will be discussed and decided. A scientific committee to prepare the workshop will be selected to carry out the practical arrangements during the year.

The WG meetings will contain common sessions to present activities by each participant relevant to the selected meeting topic (as orals or poster presentations). In addition, the WGs will hold their planning meetings, in which leaflet contents, suggestions for future topics will be discussed. In all MC meetings the WG leaders will summarise the past activities of their WG. During the second MC meetings plans to create joint meetings with other relevant COST Actions and EU –projects will be made.

Each year the WG leaders will prepare annual reports on their activities and future plans. Chair-person of the Action will prepare a compiled annual report of the Action according to the COST rules.

## **J. List of experts involved in the preparation of the proposal**

- 1. Finland**
- Dr. Johanna Buchert***  
VTT Biotechnology  
POB 1500  
FI-02044 VTT  
Tel. + 358-20-722 5146  
Fax + 358-20-772 7071  
E-mail: [johanna.buchert@vtt.fi](mailto:johanna.buchert@vtt.fi)
- Prof. Maija Tenkanen***  
Dpt. Applied Chemistry and Microbiology  
University of Helsinki  
POB 27  
FI-00014 University of Helsinki  
Tel. +358-9-19158410  
Fax +358-9-19158475  
E-mail: [majja.tenkanen@helsinki.fi](mailto:majja.tenkanen@helsinki.fi)
- Dr. Kristiina Kruus /  
Dr. Karin Autio/  
Dr. Anu Kaukovirta-Norja***  
VTT Biotechnology  
POB 1500  
FI-02044 VTT  
Tel. + 358-20-722 5143 / 5175  
Fax + 358-20-722 7071  
E-mail: [kristiina.kruus@vtt.fi](mailto:kristiina.kruus@vtt.fi).  
[Karin.autio@vtt.fi](mailto:Karin.autio@vtt.fi)
- 2. Belgium**
- Prof. Marc Hendrickx  
Prof. Ann Van Loey  
Dr. Chantal Smout***  
Laboratory of Food Technology  
Katholieke Universiteit Leuven  
Kasteelpark Arenberg 22  
BE-3001 Leuven (Heverlee)  
Tel. +32-16-321 572  
Fax +32-16-321 960  
Email:  
[Marc.hendrickx@agr.kuleuven.ac.be](mailto:Marc.hendrickx@agr.kuleuven.ac.be)  
[Ann.VanLoey@agr.kuleuven.ac.be](mailto:Ann.VanLoey@agr.kuleuven.ac.be)  
[Chantal.Smout@agr.kuleuven.ac.be](mailto:Chantal.Smout@agr.kuleuven.ac.be)
- Prof. Jan Delcour,  
Prof. Christophe Courtin /  
Dr. Hans Goesaert***  
Laboratory of Food Chemistry  
Katholieke Universiteit Leuven  
Kasteelpark Arenberg 20  
BE-3001 Leuven (Heverlee)  
Tel. +32-16-321 581  
Fax +32-16-321 997  
Email:  
[jan.delcour@agr.kuleuven.ac.be](mailto:jan.delcour@agr.kuleuven.ac.be)  
[christophe.courtin@agr.kuleuven.ac.be](mailto:christophe.courtin@agr.kuleuven.ac.be)  
[hans.goesaert@agr.kuleuven.ac.be](mailto:hans.goesaert@agr.kuleuven.ac.be)
- 3. Denmark**
- Anne S. Meyer***  
Food Biotechnology & Engineering  
Group  
BioCentrum-DTU, Building 221  
Technical University of Denmark  
DK-2800 Lyngby  
Tel. + 45-252 598  
Fax + 45-458 849 22  
E-mail: [am@biocentrum.dtu.dk](mailto:am@biocentrum.dtu.dk)
- Bente Wischmann /  
Michael Krogsgaard Nielsen***  
Food Biotechnology & Engineering  
Group  
BioCentrum-DTU, Building 221  
Technical University of Denmark  
DK-2800 Lyngby  
Tel. + 45-252 774  
Fax + 45-458 849 22  
Email: [bw@biocentrum.dtu.dk](mailto:bw@biocentrum.dtu.dk),  
[mkn@biocentrum.dtu.dk](mailto:mkn@biocentrum.dtu.dk)

***Lisbeth Olsson***

Center for Microbial Biotechnology  
BioCentrum-DTU, Building 223  
Technical University of Denmark  
DK-2800 Lyngby

Tel. +45-252 677  
Fax +45-4588 4148  
Email: [lo@biocentrum.dtu.dk](mailto:lo@biocentrum.dtu.dk)

***Birte Svensson***

Biochemistry and Nutrition Group  
BioCentrum-DTU, Building 224  
Technical University of Denmark  
DK-2800 Lyngby

Tel. +45-4525 2740  
Fax. +45-4588 6307  
Email: [bis@biocentrum.dtu.dk](mailto:bis@biocentrum.dtu.dk)

**4. France**

***Dr Estelle Bonnin***

INRA  
POB 71627  
FR-44316 Nantes Cedex 03

Tel. +33-2-406 750 58  
Fax +33-2-406 750 66  
E-mail: [bonnin@nantes.inra.fr](mailto:bonnin@nantes.inra.fr)

***Dr Nathalie Juge***

Institut Mediteraneen de Recherche en  
Nutrition (IMRN) UMR-INRA 1111  
University of Aix-Marseille III  
Marseille

Fax. +44-1603255038  
E-mail: [nathalie.juge@bbsrc.ac.uk](mailto:nathalie.juge@bbsrc.ac.uk)

***Dr Xavier Rouau***

INRA  
UMR IATE  
2 place Viala  
FR-34060 Montpellier cedex 1

Tel: +33-4-996 122 02  
Fax: +33-4-675 220 94  
E-mail: [rouau@ensam.inra.fr](mailto:rouau@ensam.inra.fr)

**5. Germany**

***Prof. Dietrich Knorr***

Department of Food Biotechnology and  
Food Process Engineering  
Koenigin-Luise-Str. 22  
D-14195 Berlin

Tel. +49(0) 30 314 71250  
Email: [Dietrich.Knorr@TU-Berlin.de](mailto:Dietrich.Knorr@TU-Berlin.de)

***Dr. Sabine Lutz-Wahl***

Department of Biotechnology  
Institute of Food Technology  
University of Hohenheim  
Emil-Wolff-Str. 14  
D-70599 Stuttgart

Tel: ++49-711/459-2313  
Fax: ++49-711/459-4267  
e-mail: [lutzwahl@uni-hohenheim.de](mailto:lutzwahl@uni-hohenheim.de)  
<http://www.uni-hohenheim.de/biotech>

**6. Iceland**

***Prof. Ágústa Gudmundsdóttir***

Department of Food Science, Science  
Institute, University of Iceland  
Vatnsmýrarvegi 16  
IS-101 Reykjavík

Tel. +354-525-4800  
Fax + 354-525-4886  
Email: [ag@hi.is](mailto:ag@hi.is)

- 7. Ireland**      ***Prof. David O'Beirne***  
University of Limerick  
Department of Life Sciences  
Limerick  
Tel. +353-61-202 845  
Fax +353-61-330 316  
Email: [david.obeirne@ul.ie](mailto:david.obeirne@ul.ie)
- 8. Italy**      ***Daniela Bellincampi***  
Dipartimento di Biologia Vegetale  
Università di Roma "La Sapienza"  
Piazzale Aldo Moro 5  
IT-00185 Roma  
Tel. +39-06-4991 2867  
Fax +39-06-4991 2446  
Email: [Daniela.bellincampi@uniroma1.it](mailto:Daniela.bellincampi@uniroma1.it)
- Laura Camardella***  
Institute of Protein Biochemistry, CNR  
Via Marconi 10  
IT-80125 Napoli  
Tel. +39-081-7257 232  
Email: [l.camardella@ibp.cnr.it](mailto:l.camardella@ibp.cnr.it)
- Alfonso Giovane***  
Department of Biochemistry and  
Biophysics 2nd University of Naples  
Via Costantinopoli 16  
IT-80138 Napoli  
Tel. +39-081-5665 917  
Fax +39-081-5665 863  
Email: [Alfonso.Giovane@unina2.it](mailto:Alfonso.Giovane@unina2.it)
- 9. Norway**      ***Prof. Vincent Eijsink***  
Agricultural University of Norway  
Department of Chemistry, Biotechnology  
and Food Science  
P.O. Box 5003  
N-1432 Ås  
Norway  
Tel. +47-64-949 472,  
Mobile +47-480 315 48  
Fax +47-64-947 720  
E-mail: [vincent.eijsink@ikbm.nlh.no](mailto:vincent.eijsink@ikbm.nlh.no)
- Dr. Svein H. Knutsen***  
Matforsk, The Norwegian Food Research  
Institute  
Osloveien 1  
N-1430 Ås  
Norway  
Phone: +47 64970334  
Fax: +47 64970333  
E-mail: [svein.knutsen@matforsk.no](mailto:svein.knutsen@matforsk.no)
- 10. Netherlands**      ***Dr. Gerrit Beldman***  
Wageningen University  
Agrotechnology and Food Sciences  
Laboratory of Food Chemistry  
POB 8129  
NL-6700 EV Wageningen  
Tel. +31-317-483219 / 482888  
Fax +31-317-484893  
Email: [gerrit.beldman@wur.nl](mailto:gerrit.beldman@wur.nl)
- Dr. L.H. de Graaff***  
Wageningen University  
Fungal Genomics section  
Laboratory of Microbiology  
Dreijenlaan 2,  
NL 6703 HA Wageningen  
Tel. +31-317-484 691  
Fax +31-317-484011  
Email: [leo.degraaff@wur.nl](mailto:leo.degraaff@wur.nl)

**Dr. Henk Schols**

Wageningen University  
Agrotechnology and Food Sciences  
Laboratory of Food Chemistry  
POB 8129  
NL-6700 EV Wageningen

Tel. +31-317-482 239 / 482 888  
Fax +31-317-484 893  
Email: [henk.schols@wur.nl](mailto:henk.schols@wur.nl)

**11. Slovakia**

**Dr. Peter Biely**

Institute of Chemistry  
Slovak Academy of Sciences  
Dubravska cesta 9  
SK-845 38 Bratislava

Tel. +421-259-410 275 / 229  
Fax +421-259-410 222  
E-mail: [chempbsa@savba.sk](mailto:chempbsa@savba.sk)

**12. Turkey**

**Dr. Vural Gökmen**

Hacettepe University  
TR-06532 Beytepe - Ankara

Tel. +90-312-297 7108  
Fax: +90-312-299 2123  
Email: [vgokmen@hacettepe.edu.tr](mailto:vgokmen@hacettepe.edu.tr)

**13. United Kingdom**

**Dr Craig B. Faulds**

Institute of Food Research  
Norwich Research Park  
Norwich NR4 7UA

Tel. +44-(0)1603-255 152  
Fax +44-(0)1603-255 038  
Email: [craig.faulds@bbsrc.ac.uk](mailto:craig.faulds@bbsrc.ac.uk)

**Dr. Keith Waldron**

Institute of Food Research  
Norwich Research Park  
Norwich NR4 7UA

Tel. +44-(0)1603-255 385  
Fax +44-(0)1603-507 723  
Email: [keith.waldron@bbsrc.ac.uk](mailto:keith.waldron@bbsrc.ac.uk)

**K. Recent publications of the partners of the proposal**

Enclosed is a list of about 5 most recent and relevant publications of each partner.

**VTT**

Kuuva, T., Lantto, R., Reinikainen, T., **Buchert, J.** & **Autio, K.** 2003. Rheological properties of laccase-induced sugar beet pectin gels. *Food Hydrocolloids* 17, 679-684.

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#### **University of Iceland**

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#### **Hacettepe University, Turkey**

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## 1. **Technical University of Denmark**

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## **Institute of Food Research (IFR)**

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## **Katholieke Universiteit Leuven - Laboratory of Food Technology**

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### **L. Industrial companies interested in the Action**

Industrial companies have been informed about the Action and interested companies are listed in Table 3. The number of interested companies is expected to increase during the Action.

*Table 3. Industrial companies interested in the Action.*

<b>Company</b>	<b>Business area</b>	<b>Contact person</b>	<b>Country, www-page</b>	<b>Interested in WG</b>
Novozymes	Enzyme manufacture	Steffen Ernst (SFFE@novozymes.com)	DK, www.novozymes.com	1, 3
Zymetech Inc.	Research and development in enzyme technology. Production of enzymes for cosmetics, food and pharmaceuticals	Prof. Jon Bragi Bjarnason, (zymetech@simnet.is)	IS, www.zymetech.com	WG1 and WG3
Danisco	Manufacture of food ingredients and enzymes	Jens Frisbak Sorensen. jens.frisbak.sorensen@danisco.com	DK	
Polttimo Companies, Research	Malting	Director Juhani Olkku	FI	2, 3
Biopolis S.L., Valencia, Spain	Microbial production of food ingredients	Dr Daniel Ramon Vidal	ES	WG1 and WG3

### **M. European and national projects related to food enzymology**

A list of current ongoing projects related to the Action is presented in Table 4.

**Table 4.** Ongoing national and EU-funded public projects related to the Action (\* national funding source)

project	Acronym	Funding source	Duration	Total budget (EU contr.)	Coordinator
Novel cross-linking enzymes and their consumer acceptance for structure engineering	CROSSENZ	EU	12/02–11/05	2.6 M€ (1.58 M€)	J. Buchert, VTT Biotechnology, FI
Novel enzyme-aided extraction technologies for maximized yield and functionality of bioactive components of consumer products and ingredients from by-products	MAXFUN	EU	1/03–12/05	3,4 M€ (2.1 M€)	K. Poutanen, VTT Biotechnology, FI
Controlled modification of proteins and carbohydrates	COMO	TEKES FI*	1/04–12/06	1,325 mE	K. Autio, VTT Biotechnology, FI
Biodegradable films from hemicelluloses	Hebika	Tekes FI*	11/04–10/06	280 kE	M. Tenkanen, University of Helsinki, FI
Enzymatic production of prebiotic xylo-oligosaccharides		Foundations FI*	03–05	50 kE	M. Tenkanen, University of Helsinki
Effects of Peroxidase, Lipoxygenase and polyphenoloxidase Enzymes on Naturally Occurring Antioxidant Compounds in Fruits and Vegetables		National TR*	2005–2006	25 000 USD	V. Gökman, TR
NorFa Network Food and Bioresource Enzyme Technology		NorFa/Nordforsk	2004–2006	110.000 Euro	A Meyer Technical University of DK
Fruit juices with improved health potential through enzyme technology		National funding *DK	2003–2007	420.000 Euro	A Meyer Technical University of DK
Exploiting bioactivity of European cereal grains for improved nutrition and health benefits	HEALTHGRAIN	EU	6/05–5/09	15.2 M€ (10.8 M€)	K. Poutanen, VTT Biotechnology, FI
Differentiation, classification and evaluation of biotechnological potential of feruloyl esterases		NATO	6/03–5/05	12 k€	C. Faulds IFR, UK
Reducing food processing waste	REPRO	EU	7/05–6/08	5.2 M€ (3.1 M€)	K. Waldron IFR, UK
Expanding the market potential for Brewer's spent grain		DEFRA UK*	09/03–02/05	172 k€	K. Waldron IFR, UK
Food Materials and Ingredients	CSG	BBSRC UK*	Ongoing core funding	2.5 M€/annum	R.H. Wilson, IFR, UK

**Additional Information**

Microbiota and microbial enzymes in wheat	MIMENTA	IWT*	10/04–9/05	335 k€	J. Delcour, C. Courtin Katholieke Universiteit Leuven
Towards a better understanding of endoxylanases and factors governing their functionality	XYLAFUN	IWT*	10/01–9/05	1,38 m€	J. Delcour, Katholieke Universiteit Leuven
Production, characterisation and functionality of (arabino)-xylo-oligosaccharides with different structure		IWT*	10/02–9/06	160 k€	J. Delcour, C. Courtin Katholieke Universiteit Leuven
Basic insight in the structural and quantitative variability of xylanase-inhibitors in wheat ( <i>Triticum aestivum</i> ) and their interaction with proteins		FWO*	10/04–9/07	225 k€	J. Delcour, Katholieke Universiteit Leuven
Study of the interplay of starch, amylases and gluten which result in bread firming		FWO*	10/04–9/07	225 k€	J. Delcour, Katholieke Universiteit Leuven
Barley beta-glucan and wheat arabinoxylan soluble fibre technologies for health promoting bread products	SOLFIBREAD	EU	10/01–9/04	1.33 M€ (1,12 M€)	J. Delcour, Katholieke Universiteit Leuven
Microbial hemicellulolytic glycoside hydrolases and esterases		Slovak Academy of Sciences and VEGA (Slovak Grant Agency)*	1/03–12/05	120 k€	P. Biely, Institute of Chemistry, Slovak Academy of Sciences
Biocatalysts for improved functional properties of foods		KULeuven*	10/03-9/07	1.2 M€	M. Hendrickx, J. Delcour, C. Courtin, A. Van Loey, Katholieke Universiteit Leuven
Inactivation kinetics and enzyme activity of endogenous pectinases responsible for structural properties of processed fruits and vegetables		KULeuven*	10/02-9/05	350 k€	M. Hendrickx, Ann Van Loey, Katholieke Universiteit Leuven
Enzyme kinetics during thermal and non thermal food processing,		EU	11/00-11/04	180 k€	M. Hendrickx, Katholieke Universiteit Leuven
Relation between enzyme catalysed substrate conversions and modifications in rheology of tomato based products after thermal and/or high pressure processing.		IWT*	1/2001- 12/2005	160 k€	M. Hendrickx, Katholieke Universiteit Leuven

#### Additional Information

Kinetics and mechanisms of pectin modification in relation to texture changes during processing of fruit and vegetables		FWO*	10/2004-9/2007	225 k€	M. Hendrickx, Katholieke Universiteit Leuven
Nutritional enhancement of probiotics and prebiotics	PROTECH	EU		1,6 mE	Dr. D. Knorr TU Berlin, DE
"Antioxidant status in minimally processed fruits and vegetables: technology optimisation to minimise losses."		national		347kE	U. Limerick
Development of modified atmosphere and humidity packaging for fresh and fresh-cut mushrooms.		national		485k, award to UL €236k.	Department of Process Engineering, UCC
Disclosing the carbohydrate modifying network of <i>Aspergillus niger</i> by functional genomics	CARBNET	IOP Genomics, Ministry of Economic affairs NL*	2002-2006	1,8 mE	Prof van den Berg, Wageningen University
Kluyver Centre for Genomics of Industrial Fermentation		Nationaal Regieorgaan Genomics*	2003-2007	17,25 mE.	Prof Pronk, Technical University Delft
Novel pectinases from <i>Rhizopus oryzae</i>		Carbohydrate Research Center-Wageningen University*	2003-2007	160.000	Prof van den Berg
New foods and materials based on starch		National funding DK*	2003-2005	1,793 k€	B. Wischmann, Technical University of DK
Role of the pectin methylesterase inhibitor in plant development and defence	COFIN2002	National Founding MURST	1/1/2003-31/12/2004	63.600 Euro	D.Bellincampi
Protein inhibitor of pectin methylesterase: studies on the enzyme-inhibitor complex topology and on its physiological role	COFIN2002	National Founding MURST	1/1/2003-31/12/2004	58.600Euro	A.Giovane
Characterization of a pectin methylesterase protein inhibitor. Role in development and defense of plants	COFIN2000	National Founding MURST	1/1/2001-31/12/2002	82.633 Euro	D.Bellincampi
Characterization of a pectin methylesterase protein inhibitor. Role in development and defense of plants	COFIN2000	National Founding MURST	1/1/2001-31/12/2002	72.304 Euro	A.Giovane

#### Additional Information

Solving problems of glycosidase inhibitors in Food Processing	Gemini	EU	1/1/2001-31/12/2003	212.620 Euro	D.Bellincampi( National principal contractor)
Carbohydrates, food quality and health	Basic project B200501	Matforsk- The Norwegian Food Research Institute	01/05 – 12/08	1200 kE	Svein Knutsen, Matforsk
Proteolysis in foods: quality and biological function	Project no. 419104	The Research Council of Norway	08/01 – 12/04	430 kE	T. Sørhaug, IKBM Agricultural University of Norway
Bioactive peptides from milk whey and their applications in health foods	Project no. 719006	NORAD - The Norwegian Agency for Development Cooperation	10/02 – 09/06	160 kE	G. Vegarud, IKBM Agricultural University of Norway
Characterization and engineering of enzymes for the conversion of chitin and related polymers	Project no. 419009	The Research Council of Norway	07/01 – 06/06	1150 kE	V. Eijsink, IKBM Agricultural University of Norway
Protein-oriented studies of the interaction between potato and <i>Phytophthora infestans</i> ; identification and characterization of enzymes involved in infection	Internal project	The Agricultural University of Norway	04/02 – 12/07	250 kE	V. Eijsink, IKBM Agricultural University of Norway
Industrial development of fish-based peptones	Project no. 819008	The Research Council of Norway & Maritex AS (owned by the Norwegian Dairies)	01/02 – 06/05	500 kE	V. Eijsink, IKBM Agricultural University of Norway
Atlantic salmon - our most important raw material for food production: knowledge basis for increased pre-rigor processing in Norway.		The Research Council of Norway	10 / 2003 - 06/2008	1.8 million Euro	Prof. Magny Thomassen, Department of Animal and Aquacultural Sciences, Agricultural University of Norway

#### Additional Information