PNRA
APPEL A PROJETS 2007

Dossier de soumission

Date limite de dépôt des dossiers : 09/05/2007

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Programme PNRA Edition 2007
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Contacts :

http://www.inra.fr	Correspondantes dans l'unité support de l'ANR: - pour toute information scientifique ou technique concernant l'appel à projets (AAP) : ESNOUF Catherine (esnouf@paris.inra.fr) ; tél. : 01 42 75 91 51 - pour toute information de nature administrative et financière : RABUT Marie (rabut@paris.inra.fr) ; tél. : 01 42 75 93 60 CRESSON Céline (celine.cresson@paris.inra.fr) ; tél. : 01 42 75 95 18

LA MISE EN ŒUVRE DE L'APPEL A PROJETS EST REALISEE PAR L'INRA QUI A ETE MANDATE PAR L'ANR POUR ASSURER LA CONDUITE OPERATIONNELLE DE L'EVALUATION ET L'ADMINISTRATION DES DOSSIERS D'AIDE.

[1] La description scientifique et technique du projet devra être rédigée de préférence en anglais. Au cas où la description scientifique et technique serait rédigée en français, le coordinateur du projet concerné devra fournir une traduction en anglais à l'INRA, unité support de l'ANR, dans un délai de dix jours, si le comité d'évaluation désigne un ou des experts externes étrangers non francophones pour les expertises.

PNRA
APPEL A PROJETS 2007
Dossier scientifique n° 4.1P

COORDINATEUR (SCIENTIFIQUE ET TECHNIQUE) / **Project scientific leader**		**Organisme ou Entreprise/ Organisation**	
Nom/ Family name	**RENARD**	**Unité (si organisme)/Unit**	INRA
Prénom/ First name	**Catherine**	**Directeur/Responsable/Laboratory head**	UMR A 408 SQPOV
Titre/grade	**DR2**	**ADRESSE**	
		N° rue	Domaine St Paul
Tel	**04 32 72 25 35**	**BP**	
Fax	**04 32 72 24 92**	**Code postal**	84914
Courriel	**catherine.renard@avignon.inra.fr**	**Ville**	Avignon

Titre du projet

Des procédés innovants pour proposer des produits transformés à base de fruits aux qualités organoleptiques et nutritionnelles optimisées.

Title of the project

New processes for production of fruit-derived products with optimised organoleptic and nutritional qualities

ACRONYME/ ACRONYM (maximum 20 caractères)

TEMPANTIOX

Signature du coordonnateur du projet	**Signature du Directeur d'Unité ou du Directeur de l'entreprise**
	Fonction, nom, prénom

Résumé en français en 1000 caractères maximum (espace non compris)

Ce programme vise, par une approche d'ingénierie réverse, à proposer des produits qui élargissent la gamme des possibles par leur texture ou leur teneur en micronutriment pour constituer un support organoleptiquement attractif et riche en composés d'intérêt nutritionnel (antioxidants, fibres). Les desserts fruitiers de type purée avec morceaux ont démontré leur attractivité mais restent difficiles à produire avec les procédés classiques. De même les méthodes usuelles de production des jus de fruits ne valorisent que partiellement la teneur en antioxydants des fruits.
Des procédés innovants, choisis pour leurs impacts potentiels sur les deux cibles d'action que sont la cuisson de morceaux sans surcuisson de la phase porteuse et l'extraction des polyphénols, vont être mis en œuvre. Leurs impacts sur les caractéristiques organoleptiques, chimiques et physiques des produits seront mesurés afin de pouvoir modéliser les relations entre paramètres des procédés et nature et propriétés du produit obtenu. L'acceptabilité de ces produits sera étudiée en confrontant leurs caractéristiques et le ressenti du consommateur vis-à-vis de l'innovation et de la nutrition.

Abstract in english 1000 characters maximum

The aim of this program is to use a reverse engineering approach to propose new fruit-based products that have innovative textural attributes and improved micronutriment. The products will combine sensory attractiveness and richness in compounds of nutritional interest compositions (antioxidants, fibers). Two specific targets were chosen. Fruit-based desserts such as chunky fruit purees have behaved well in the stores but remain difficult to produce using classical means. Conventional juice production leads to a limited valorisation of the phytonutriments of the fruits.
Innovative processes, chosen for their potential to impact the two targets (cooking of chunks without overcooking the carrying puree, and enhanced extraction of polyphenols from the fruit matrix), will be used. Their impacts on sensory, chemical and physical characteristics will be measured in order to modelise the relationships between the parameters of the processes and the properties of the products. Acceptability of the products will be studied by confronting their properties and the attitudes of the consumers towards innovation and nutrition.

DESCRIPTION DU PROJET SCIENTIFIQUE/*SCIENTIFIC DESCRIPTION*[2]

Maximum 20 pages (hors CV, publications et fiches descriptives des unités), answers of all items must be given (police Times New Roman 12 ou Arial 10)

1 - MODIFICATION DEPUIS LE PROJET SIMPLIFIE (partenaires, budget, programme)/ CHANGES SINCE THE SHORT PROPOSAL (partners, budget, research program) (½ page maximum)

There has been only limited changes since the short proposal.

- No changes to the partnership.

- Budget : a Ph.D. thesis originally planned to be entirely financed within the project will be co-financed – a post-doc planned to work on puree texture has been replaced by participation of a Ph.D. student (in cooperation with industry Héro France). Amounts for private partners have been increased. Minor changes in exact amounts attributed to the different partners and their distribution. Taxes and environment costs have been calculated according to the ANR template.

- funding for students now appears.

- Work program: preparation of apple purées for qualification of texture will start earlier.

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2 - CONTEXTE ET ETAT DE L'ART / *CONTEXT AND STATE OF THE ART* (2 pages maximum)

- Socio-economic context

In spite of information campaigns such as « Plan National Nutrition Santé », which advocate the 5-a-day message, and a good image in the general public, consumption of fruits and vegetables in France does not register significant increases, at best a stabilization of the amount eaten per person per year. One of the hindrances seems to be that fresh fruit and vegetables lack convenience, and their preparation is perceived as time-consuming, while processed products such as preserves or canned fruits do not convey the fashionable images of "freshness" and "naturalness". Recent trends indicate a shift toward highly processed products such as juices and "smoothies", and a positive impact of the presence of compounds with an nutritional added value such as anti-oxidants (e.g. in cranberries, pomegranate …). There is thus an open field for processed product innovation in the fruit and vegetable chain, provided this innovation brings advantages in convenience, sensory or nutritional value. Such diversification has been achieved by the dairy product industry and could be of great benefit to the fruit and vegetable consumption.

Fruit transformation in France (outside juices and fermented drinks) use 750 000 T of fruits per year for a production of approximately 430 000 T (data 2003)(1), out of which 58 000 T of fruits in sirup, 240 000 T of purées and sauces, with a large majority of apple-derived products (200 000 T), followed by peaches and pears. Evolution of this market shows a slight increase, more in value than in volume. Cider is produced from dedicated apple cultivars and orchards, representing approximately 200 000 T of apples / year for a sale volume of 1.2 million hectoliters. An additional 30 000 T of cider apples are processed into juice, also for dedicated use (exportation to Spain and Great-Britain for cider production). However most commercial apple juice is obtained by dilution of world-market concentrates, with a heavy price pressure brought notably by exports from China. Offering a clearly differentiated premium product is therefore an aim for preserving use of local fruit production.

- Scientific context

Polyphenols and plant cell walls (as dietary fibers) are some of the compounds involved in the positive effects of fruits and vegetables on health. They also have a strong impact on their organoleptic properties (notably colour and texture) and those of processed products. Our aim is here to know and understand impact of key steps of the processed on the fate of polyphenols from the fruit to the final product, and in particular to understand the roles of the plant matrix and of interactions between its various components.

In spite of the recent interest in polyphenols and numerous studies devoted to identifying their main sources in food, there has been few studies on their fate during fruit and vegetable processing, in spite of proven major impact of processing and of the fact that most plant food is consumed processed. Polyphenol concentrations in apple juices are much lower than in fresh apples: they have been estimated to represent between 5 (2) and 30% (3) of those in the apples. The extraction ratios of the different classes vary greatly (3, 4): *p*-coumaroylquinic acid, which is not subjected to enzymic oxidation nor adsorbed onto the cell walls, is almost quantitatively extracted; lower extraction is obtained for chlorogenic acid, the direct substrate of PPO, and lower again for monomeric catechins, which are included in secondary oxidation phenomena; procyanidins, and specially those with high polymerisation degrees, are even less extracted (<30%); finally, the quercetin derivatives, specific for epiderm in most apple cultivars, are hardly present in juices from direct pressing. For heat-processing, most interest has been focused on flavonols, for which a major cause of losses is peeling (5), as these compounds are usually concentrated in the peels. Another significant factor is leaching in the cooking /canning water (6,7,8), which further depends on the conjugate. Vallejo et al (8) compared the impact of various cooking modes for broccoli. Microwaving led to disappearance of most phenolics, while steaming had minimal effects; during conventional boiling and high pressure boiling, decrease of the contents of phenolic compounds in the florets was due to both leaching in the cooking water and thermal degradation. In pear sections, procyanidins were actually retained in the sections (9), probably by interaction with the cell walls, while other polyphenols were leached partially in the cooking water.

We have identified three phenomena which can lead to polyphenol losses. First is the enzymatic oxidation of polyphenols, which itself will depend on the presence and stability of polyphenoloxidase, and on the presence of oxygen (10). The second is their thermal degradation, influenced by physico-chemical conditions such as pH and presence of ions (11). The last is their insolubilisation by complex formation with the food macromolecules (proteins and cell walls) (12). Another mechanism to be taken into consideration is the destructuration of the plant matrix and membranes, brought by thermal of physical processes (from grinding to electroporation): will it facilitate diffusion of the polyphenols, which can be an advantage when extraction processes are used, or contribute to their loss by leaching?

Our results, and more specifically the models which we plan to elaborate, will permit, by a more integrative approach of the plant matrix, to better understand how the nutritional qualities of processed fruits and vegetables are built, and which are the key factors and steps. To have a comprehensive view of these

phenomena, we will use two model products, one in which enzymatic oxidation will be the favoured mode of evolution of polyphenols (apple must) and one in which thermal aspects will dominate (chunky fruit dessert); For both we will consider the reactivity of the main polyphenol classes of apple with the plant cell walls and how it varies for newly formed products. Beyond the fact that they represent the two modalities of polyphenol evolution (enzymatic / thermic), these products have been chosen for their attractivity to the consumer, difficulty in producing using conventional techniques and their potential for valorisation of nutritionally interesting compounds. Polyphenols, cell walls and ascorbic acid are pertinent tracer molecules both from a nutritional and organoleptic point of view. Polyphenols are the substrates for enzymatic browning and antioxidants, ascorbic acid is added as a processing aid to preserve colour (anti-browning agent) and cell walls determine the texture of fruit purées and chunks while contributing to the dietary fibers.

Emerging technologies such as pulsed electric fields, high pressures, ohmic heating, microwave or ultrasound, have met difficulties in being adopted in food industries. The work which has been pursued for example in Belgium (at KU Leuwen on juices and high pressure by the group of Prof. Hendricks), in Spain (at CSIC Madrid on meat products) or in Germany (at TU Berlin on use of pulsed electric fields) have clearly demonstrated that such processes can find a place and bring enhanced attractivity and qualities of foods. Ohmic heating is a food processing method in which an alternating electrical current is passed through an electrically conducting food sample and the inherent electrical resistance of the material generates heat (13-15). This produces a heating pattern from within the food, which is much faster than conventional outside heating. The expected advantages are reduced enzymic and thermal degradation by eliminating the lengthy heating step. Electroinduced formation and growth of pores in cellular membranes (electroporation) is a main effect of PEF, favourable for extraction of solutes from interior of cells (16-19). Ultrasound also can lead to enhanced extraction of solutes (20). The biophysical impacts of ultrasound can be characterized as thermal effects, cavitation and direct effects. Ultrasound can improve heat, material or movement transfers and modify enzyme kinetics. In aqueous media the non-thermal effect is attributed mainly to cavitation (21). Both PEF and US have been up to now mostly been investigated for destruction of microflora and issues related to preservation/enhancement of food safety (22-24). However these applications require high voltage PEF (20-40 kV/cm) or high energy US. Because the size of the cells to be affected is much bigger (plant cells instead of bacteria), we expect that much lower energy loads will be needed to enhance pressing. Moderate voltage PEF (0,5-1,5 kV/cm) will be evaluated; it has been shown to increase juice yields in pilot trials (16, 19) but the qualitative aspects have not been evaluated nor the insertion in a continuous process.

Our aim is to use innovative processes to increase nutritional density in fruit products. This will be done either by increasing retention of native polyphenols in solid or semi-solid food products (by decreasing oxidation, diffusion or hydrolysis) or on the opposite by increasing their extraction in liquid products through electroporation (PEF) or cavitation (ultrasound).

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3 - OBJECTIFS DU PROJET et CARACTERE INNOVANT DU PROJECT/ *PROJECT AIMS AND INNOVATIVE ASPECTS*

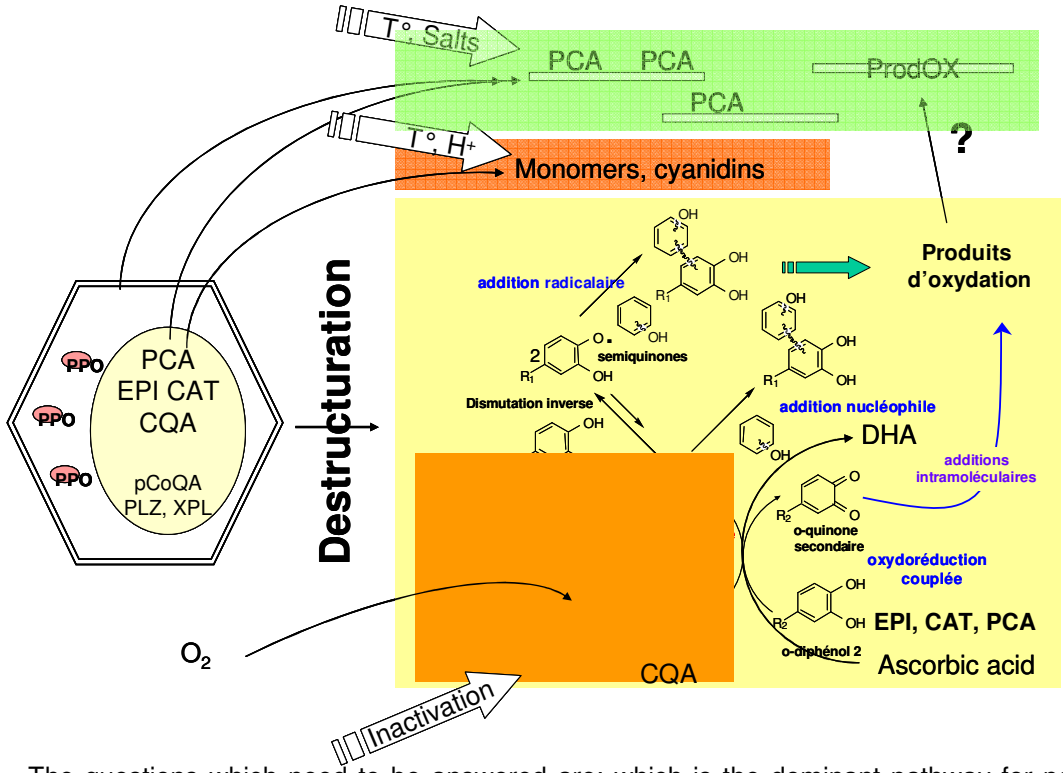
(3 pages maximum)

Préciser :

- Les objectifs fixés : scientifiques et socio-économiques

Emerging technologies have been studied for application in the food industries mostly because they can bring faster and more economical productions and increase food safety. They can also lead to different textures, aromas, organoleptic and nutritional values which could satisfy the demands of the consumers. Our aim is to use these emerging technologies to modulate the fate of polyphenols and cell walls, particularly for their availability and organoleptic properties in the final product.

The scientific aim of the project is to quantify and integrate the various pathways which polyphenols (and cell walls) can follow during the processing steps, while being aware that individual mechanisms are not yet totally understood. Our view of the different pathways is summarised in the scheme below:



The questions which need to be answered are: which is the dominant pathway for polyphenols in the different process conditions, between enzymatic oxidation (in yellow), thermal degradation (in red, including autooxidation and acidolysis depending on pH and ionic composition), and binding to the cell walls (by physico-chemical or covalent bonds)? Is the stability of polyphenoloxidase (PPO) modulated by its inclusion in the fruit matrix? Are polyphenols more or less freely available after heat treatment? Which interactions with the other constituents notably ascorbic acid (added as processing aid), polyphenoloxidase and oxygen, and cell walls). How to facilitate extraction of skin polyphenols? How do cell wall polysaccharides partition between the particles and the liquid phase, with which consequences for the texture and for interactions with polyphenols?

We will study in a dedicated workpackage the kinetics of degradation, the mechanisms of stabilisation and the mutual protection rôles of the different moeities, so as to understand which is the dominant pathway in which conditions. Use of synthetic / reconstituted media will allow to study in detail the mechanisms involved, identify and vary in controlled manner their key conditions and impact points. These potential impact points will be validated by production at a pilot scale of fruit products and verifying that the expected characteristics have been acquired with specific conditions.

The links between the molecules and the sensory, nutritional and technological qualities which we aim for are summarised here:

	Polyphenols (ascorbic acid, PPO)	Cell walls
Fruit dessert	Colour, availability	Texture, adsorption of polyphenols
Juice	Colour, extraction efficiency	Retention of polyphenols, juice yields

The applied aims of this project are to use emerging technologies to propose new products that will widen the range of available products either by their texture (chunky fruit dessert) or their high concentrations in micronutriments (apple juice, fruit dessert), and to present firm data on the nutritional qualities of processed fruit products. We plan to have products which will be convenient, attractive by their colour, taste and texture, and enriched in compounds of nutritional interest. They should have lighter and brighter colours, and have been submitted to less drastic heat treatments, so that they should answer the expectation of « freshness » of the consumers. Priority segments of population could be either senior citizens or children but will in any case be precised by preference mapping and marketing studies. The approach used should be transferable to other fruits or vegetables-based products.

For that we use a reverse engineering approach, where we take into account the preferences of the consumers to define the characteristics of the products to be produced and modelisation to fine-tune the processes to obtain these products. We aim to establish the relationship between nutritional, physical and sensory properties (colour or texture) of the products on the one hand and the variables of the processes on the other hand. This will be used to obtain specific desired properties of the products, themselves defined by consumer interrogations or tests (e.g. preference mapping).

Two products will be specifically prepared. The chunky fruit dessert will consist in pieces in the order of size of one centimetre in an apple puree. Because of the speed advantage of ohmic heating, particularly for heating of particulate foods, we expect a faster denaturation of polyphenoloxidase (i.e. decrease the occurrence of enzymic browning) and a cooking of the pieces without overcooking of the puree in which they will be embedded. Heat treatments have also a strong impact on the plant cell walls: degradations of some of their polymers modify their supramolecular structure and porosity. The texture of the resulting products, such as fruit purees, is still little understood. These physical characteristics play a major role both for the sensory perception of the product and for the process itself as this puree phase must be able to act as a carrier for the chunks. The perception of the texture of the purees and of the impact of the presence of chunks (with more or less contrasted texture) will be evaluated both by sensory analysis and preference mapping. For apple juices, we have shown that the determining step for polyphenol composition is the pressing, during which both enzymic oxidation (allowed by the preliminary fragmentation of the fruits) and adsorption on cell walls occur. We will therefore seek to act at this step by modifying the contact conditions between polyphenols, polyphenoloxidase and oxygen, and cell walls. The effects of electroporation induced by pulsed electric fields, combined to the intrinsic semi-permeability of the plant tissues allow to retain or not some of the dispersed molecules (pectins, procyanidins, enzymes, subcellular particules) during juice preparation. At high intensity, ultrasound waves generate intense and localised pressures and stresses, as well as temperature gradients through the material. The material can be fractured or some reactions (chemical or biochemical) be enhanced. Ultrasound also results in almost instantaneous degassing of liquids, thus eliminating the dissolved oxygen implied in enzymatic oxidation. As oxygen is the limiting factor for oxidation in cider processing, this could have direct effects on colour and transfer of native polyphenols.

In both cases, the processes will be confronted to “conventional” methods both for their products (colour, taste) and for their technico-economic consequences (energy use, yields, adaptation to further steps).

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- L’originalité et le caractère novateur du projet

The originality of this project resides in its integrative approach of the phenomena involved during the processes and in its goal-oriented use of emerging technologies: their use specifically to modify the organoleptic and nutritional properties of fruit products is an original point. We aim to study not the effects of the processes on the molecules but how the intrinsic properties of the molecules and the interactions between the different classes and the food matrix determine the impact of the physico-chemical conditions during the processes. This integrative approach will allow us to understand the mechanisms associated to the evolution of the compounds and their properties, in relation with the variables of the processing steps. It determines our work plan which combines observation of actual processes and experiments in model solutions and suspensions to formulate mechanistics models and validate them through manipulation of the process variables.

The consortium brings together two separate groups of teams; we will integrate the strong points of both these groups. Mutual knowledge was a key point for building this project, in which exchanges of personnel and material are planned to optimise use of resources. These teams variously participate in the main recent projects (European or national) on related subjects. The PI “ISAfruit” uses plant breeding as the main tool for product innovation, and relies on proved technologies for processed products. The products we have chosen to study are complementary to those addressed in ISAfruit (fresh-cut, sous-vide, dried and conventional juices). The ANR project “REACTIAL”, as well as the PI “LYCOCARD” focus on the fate of polyphenols or carotenoids in conventional heat and mechanical processing. The food technology tasks of the STREP “FLAVO” also used proven technologies. The PI Novel-Q, which aims at enhancements to the state of the art of novel processes, will focus on food safety issues: high pressure processing (HPP) for sterilisation of food, quantitative studies on the effect of pulsed electrical fields (PEF) on food pathogens and cold plasma as a surface disinfecting method.

In particular, though we will check the impact of the pretreatments on the microflora of apple musts, we do not aim at sterilisation of this product, which will undergo fermentation. The intensities of treatments used will be notably less drastic that those required for sterilisation.

- Les verrous scientifiques et/ou technologiques à lever

The main points of this project are:
- characterization of the mechanisms of polyphenol modifications during processing, specifically study of their interactions with the food matrix;
- characterization of the modifications of the cell wall polysaccharides, because they will modify their capacities for interaction with polyphenols and the texture of the fruit purees and pieces. Some effort will be dedicated to describing and understanding this texture;
- well-identified couples of process / aim (improve extraction for juices, decrease thermal degradation for purees) and the presence of industries directly concerned by evaluation of processes and products;
- a link with the consumer's perception of the actual products but also of innovation in the agri-food chain. This appears to be a key point for acceptation of the new products.
Integrating the various factors that can influence the fate of polyphenols in a food product is a challenge in itself. It will demand a hierarchisation of the different possible pathways and their kinetics, and a judicious choice of the initial hypotheses. We will be helped by the previous expertise of the participants, and in particular their knowledge of the enzymatic oxidation pathway and of polyphenol / cell walls interactions. Demonstrating the integration of innovative technologies in existing processes or conception of adapted processing streams will be attempted. The main scientific barriers may potentially arise from a lack of knowledge on reaction pathways, the choice of markers, and the access to kinetics on heterogeneous solid products. The main methodological and implementation barriers may arise from the analytical methods, and from the heterogeneity and the variability of products and raw materials.

- L'adéquation du projet avec les axes et les critères de l'appel à projet.

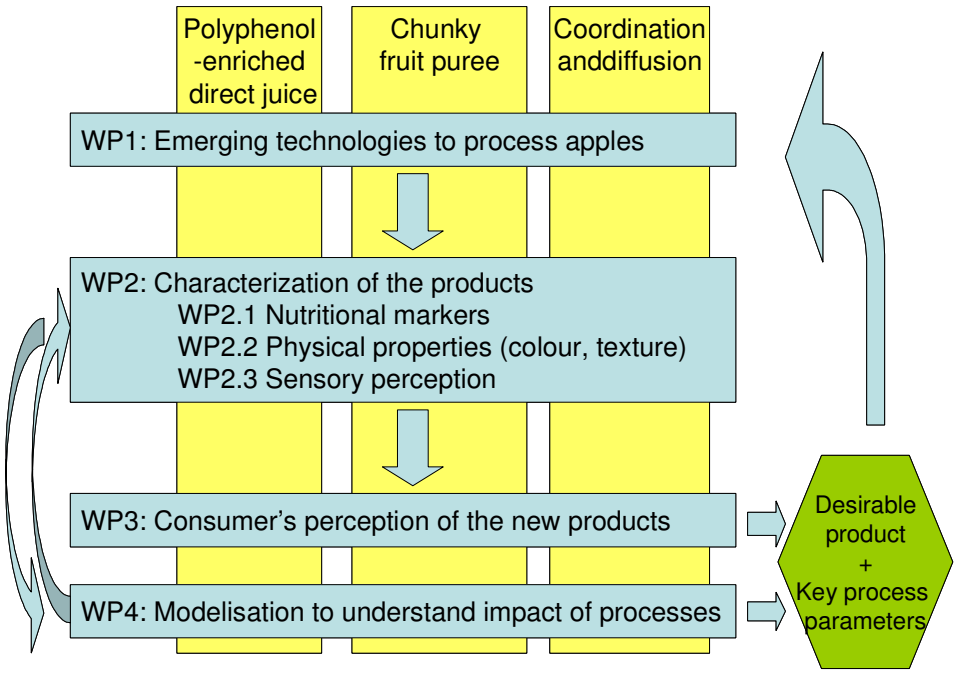
This project will directly contribute to the goals of the call for proposals, notably:
- "Increase knowledge and bring innovations related to nutritional and/or sensory qualities": this is the main aim of our project, in which we also "take into account several quality criteria", namely sensory and nutritional.
- "in harmony with environmental criteria": the technologies used should allow preparation of the products with lowered energy costs compared to conventional methods. This has already been shown for ohmic heating and we plan to validate the technico-economic data for pre-treatment prior to juice pressing. The intensities of treatments (and therefore their energy use) will be notably less drastic that those required for sterilisation.
It is related to one of the priorities of the 2007 call: "evolutions of technologies and food processes in answer to criterias of quality and/or security of products" and addresses the fruit and vegetable sector.

Specifically, it belongs to axis 4 "Food technologies and processes". It is a project in public / private partnership (two of the private partners contribute to the project at a higher level than the contribution of ANR), which will produce data on "coupling and/or integration of innovative technologies… for a better quality of the products (texture, nutritional quality)". We will attempt a reengineering of food processes (juice extraction, cooking of pieces in a viscous heterogeneous matrix) with an integrated multicriteria approach aiming to improve organoleptic and nutritional qualities. One of the workpackages (WP 3) specifically considers the impact of use of innovative processes on the image the consumer has of the products (up to "willingness-to-pay" considerations).

It will also be a medium for a better integration of teams working on processing of fruits and vegetables. Though a number of us have participated / participate together in various European and national projects, this has been in a scattered manner, and we have never formalised this network in a concerted integrated approach, as we will do here. We now can cover the whole chain of means and expertise from characterization of fresh fruit physiology to consumer science, with a strong emphasis on process engineering and biochemistry. SMEs of the food sector are full partners in the project, to which they will contribute financially, by recruiting specific personnel, by dedicated productions, by their expertise and by industrial scale trials of new technologies.

4 - ORGANISATION DU PROJET / *TECHNICAL DESCRIPTION AND PROJECT ROADMAP*
(10 pages maximum, hors publications et fiches descriptives des équipes)

The organisation of the project is summarised here:



Its schedule will be iterative, according to the seasonality of fruit production and the necessity of characterizing the products of one step to identify the influent parameters and formulate precisely the next series of experiments in close link with modelisation. In addition, we have planned an increase of scale along the duration of the project. Year 1 will be used for study of feasibility of the different processes and to identify the usable range of the parameters. We will begin stoechiokinetic modelling in synthetic or reconstituted media. A survey will be carried out to identify in which conditions innovative processes can be accepted by consumers.
End of year 1 (apple harvest) should see the first pilot plant scale juice productions, beginning of year 2 the chunky fruit desserts. These products will be analyzed during year 2 so that we will have clear indications for the model building and identification of the control parameters for an eventual next series of production, which will be analysed to validate the models. Sufficient products should then be available for consumer experiments and preference mapping. Year 3 should specifically see a full-size trial of the impact of pre-treatment of apple mash on juice quantitative and qualitative yields.

WP 1 Use of emerging technologies for processing of apples

WP 1 is concerned with the processing of apple to obtain products with enhanced nutritional and/or organoleptic qualities. To reach this purpose new available technologies will be tested on processing of purees with added fruit pieces (WP 1.1) and on apple juice making (WP 1.2).

Task 1.1 Chunky fruit dessert

The challenge of the process is both to modulate the texture of the puree and pieces to vary the mouth feel and to improve the phytonutriments content and stability (dietary fibers, antioxidant polyphenolic compounds and vitamin C). Heat treatment is the main step on which attention will be focused to reach this goal.
Ohmic heating is an innovative technology, which performs a volumetric heating within the product combined with a high electrical yield. It currently focuses the attention of food industrialists due to the nutritional and organoleptic benefits induced by this process, as it avoids the necessity for heat diffusion from heating sources of classical technologies. It allows the development of new products. During the European research program NovelQ, P2 CTCPA carried out a detailed technico-economical assessment of the different technologies notably ohmic heating. Higher initial investment costs were quickly offset by the much more efficient use of energy.

Sub-Task 1.1.1 Contrasted purees

The aim of this task is to produce purees with significantly different viscosities for task 2.2 (Deliverable 1.1.2). P2 CTCPA will prepare the first year purees from Braeburn and Reinette apples, which are texturally different. They will be processed at two ripening stages (end of starch regression and plus 2 months at 4°C). This should allow

us to use the characteristics of the plant material to modulate the product properties with a uniform process. Hot break processing of washed apples will lead to purees with a high level of graininess (grate size = 1.5 mm). The puree will be heated at 92 °C for 10 min, then degassed. The solid mater will be adjusted by concentration and after heating at 92-93 °C using a Stefan cooker the puree will be hot filled in 1/1 can. Four different purees (50 kg each) with different viscosity levels will be obtained.
If the textures of the purees are deemed too similar, we will attempt use of cold break process.

Sub-Task 1.1.2 Preparation of chunky fruit desserts

The second year three purees will be prepared by P11 according to a selected set of conditions (fruits and/or process) to obtain final products with distinct rheological behaviours (low, medium and high viscosity). P11 Héro will process about 3000 kg of each base puree in 150 kg cans (Deliverable 1.1.4). P2 CTCPA will prepare fresh cut apple centimetric pieces (tentatively Granny Smith) to be added to the 3 purees.
To precise the ohmic process conditions, electrical conductivites will be measured in a static cell by applying a weak alternative electric stream of intermediate voltage (10 – 100 V) between two titanium plates, which act as electrodes in a small rectangular cell filled with the product to be evaluated. This will be carried out individually for all carrying phases, for chunks and for their admixture.
The mix pieces + carrying puree will be immediately treated by ohmic heating or by using a Stefan cooker for control samples. In case of ohmic heating, two pasteurisation values (PV) levels (high and low) will be chosen. For each PV a high temperature short time treatment and a low temperature long treatment will be performed in order to evaluate the cooking effect on products qualities. The 15 chunky desserts (3 controls + 3 purees x 4 heat treatments) obtained in this task will be packaged in 1/1 cans for analysing (WP 2). Heat treatments will be recorded to be correlated with analysis data (Tasks 2.1 and 2.2) and sensorial analysis (Task 2.3) (Deliverable 1.1.5).
If the initial purees are not able to act as carrying phase, an hydrocolloid will be added to ensure the existence of a flow threshold. If the texture of the chunks is not differentially affected by the process, we will attempt to either presoften them (precooking) or enhance their texture by incubation with calcium.

Task 1.2. Emerging technologies to produce high quality juices with enhanced polyphenol contents

High quality fruit juices, which are naturally enriched in nutritional components, can be obtained using new technologies to favour the transfer of such components from mash to juice. In apple some phenolic compounds are adsorbed on the cell wall material of the pomace during the juice extraction. Due to the polyphenoloxidase activity, some native polyphenols are oxidised and lead to brown pigments. Pre-treatments of the mash could modify both the transfer and the oxidation of phenolic compounds during squeezing. Moreover the juice stream through the cell wall solubilises some polysaccharides which are dietary fibers. Two emerging technologies, namely pulsed electric fields and ultrasound, will be used combined to conventional pressing to enhance extraction of solutes from apple cells, particularly from epidermal cells, by enhancing or modifying tissue disruption. In both cases we will combine methodological studies, carried out at laboratory scale either by a post-doc (P7 GPI) and Ph.D. students (P1 SQPOV, P3 URC), with pilot plant scale extractions, carried out either at P3 URC or at P7 GPI. Finally industrial scale trials are planned at P9 Val-de-Vire (PEF). All material requirements have been identified for PEF trial and P10 REUS is specialized in US equipment and will furnish a pilot scale equipment to P1 SQPOV (D1.2.1). Care will be taken that the same instrumented presses are used in the laboratory trials (together with similar or comparable fragmentation of the apple tissues). These will be used to understand the impact of the various variables of the treatment, and optimise them, while the pilot scale trials will help us to understand at which precise point of the process maximum efficiency is obtained.

Electroinduced formation and growth of pores in cellular membranes (electroporation) is a main effect of PEF, favourable for extraction of solutes from interior of cells. In commonly applied PEF treatment schemes the simplified protocols are used as a rule. In such protocols the electric field strength E, pulse duration t_p and number of pulses n are fixed to obtain a desirable degree of tissue damage. It is assumed that the damage degree Z is determined by the total PEF energy input W or the total PEF processing time (defined as $t_{PEF} = n \times t_p$) at a given value of E. However, such protocols are not proved theoretically and experimentally. Moreover, the unambiguous power consumption protocols are not established yet. The difficulties in optimization of PEF processing are related to number phenomena induced by PEF in cellular structure, such as releasing of intracellular liquid, solutes diffusion and membrane resealing processes developing after the treatment. Specific effects like electroosmotic flowing and electrolysis phenomena can also be important. The optimal protocols of PEF treatment require the detailed knowledge how the damage degree Z and specific effects induced by PEF depend on E, t_{PEF}, t_p, period between pulses Δt and temperature T. The PEF protocol depends noticeably on type and structure of a biological material, size of cells, thickness of cell walls, ionicity of cell liquid, humidity and degree of material fragmentation. The history of material transformation and type of PEF assisted processing (e.g. pressing, diffusion, drying, rehydration, etc…) can also be important.

When ultrasound waves propagate through a liquid, molecules oscillation leads to compression and depression zones. According to the characteristics of the liquid, high-intensity sound waves can overlap the internal cohesive forces of the liquid and partial vacuum bubbles occur inside the liquid, which is locally vaporized; dissolved gases are consequently escaped . Power ultrasound thus enhances chemical changes in a liquid medium through the formation and destruction of cavitation bubbles. This cavitation phenomenon is well described both theoretically and experimentally. In solid material US waves compel high stress and shear with together temperature increase. The solid can fail and some chemical or biochemical reactions can be activated. Because it is able to perforate the cell walls and destruct the cellular structures, it should enhance extraction of the apple skin polyphenols, for which diffusion appeared to be the limiting factor. Ultrasound can be used to extract natural products as it allows fast, high extraction yields from compounds, including anti-oxidants, from plant matrixes (20). In our case, US has the further advantage of almost instantaneously degassing the medium, i.e. eliminating among others oxygen and this should also contribute to a sharp decrease in enzymic oxidation phenomena. Thus it is expected that US processing of apple mash before squeezing will enhance the yield of phytonutriments extraction and will improve the organoleptic qualities of juices.

Both processes include as parameter the fragmentation state of the apples in the mash and the presence of instertitial liquid. We will attempt to understand the impact of these parameters in laboratory trials and control this them in pilot trials.

Sub-Task 1.2.1 Optimising mash treatment

Apple cultivars (cider apples Kermerrien, Dous moen, Judor) are chosen according to their phenolics content and their tendency to browning. “Table” apple Golden delicious may be used for off-season methodological studies as it is available all year. First year experiments will be carried out at laboratory scale (3-4 kg each run). Apple mash with two different particle size will be treated by either PEF or US. The samples of apple tissue will be PEF treated allowing to control polarity and all protocol (E, t_{PEF}, t_p, Δt, T) and to measure electric conductivity and temperature in the course of the treatment. In US protocol temperature (2 levels), power of US (2 levels) and time (2 levels) will be tested. Control and treated mash will be pressed and time-pressure-yield diagrams will be recorded on an instrumented press. Mash, pomace and juice samples will be collected and appropriately stabilised for analysis of phenolic compounds, cell wall material, polyphenoloxidase activity and juice characteristics (Deliverable 1.2.2).

Sub-Task 1.2.2. Mash structure measurement

After PEF treatment the mash samples will be examined with LRC meter (up to frequencies of 10^6 Hz) and texture analyzer. The tissue damage degree will be estimated by comparison of electrophysical (disintegration index) and textural (module of mechanical strength, relaxation) tests. Theoretical and numerical calculations (with application of Monte Carlo and percolation models) are required in order to derive the optimal treatment protocols. The input parameters of these models will be derived from electrophysical experiments. The application of electronic microscopy allows to determine the level of PEF or US induced structure disintegration. After pressing the porosity and rehydration capacity of the pomace will be estimated by capillary impregnation and diffusion-conductometric methods, respectively. (Deliverable 1.2.3).

Sub-Task 1.2.3. Pilot trials

During apple season mash treatments will be carried out at pilot scale (15 to 100 kg) and juices will be obtained using either continuous or batch pressing. The aim of these trials is the validation of the optimal conditions defined according to the previous laboratory studies, and verification of the impact of the two pretreatments on yields, composition and the “functional” characteristics of these juices.
As PEF requires specific infrastructures, pilot scale experiments will be carried out at P7 GPI by a co-tutored (with URC) Ph.D. student. Pilot plant US trials will be conducted by P1 (F. Chemat and Ph.D. student) at P3 URC using the power US pilot build by P11 REUS. In order to obtain comparable data within the project, pilot plant trials will be organized in a short time slot using a single batch of apples. Musts will be clarified using depectinisation and ultrafiltration. Mash, pomace and juice samples will be collected for appropriate analysis (Deliverable 1.2.4).

Sub-Task 1.2.4. Industrial processing

At the end of the second apple season a mobile PEF equipment will be set up in the production plant of P9 Val-de-Vire. Evaluation of the installation in the flow sheet of the production line will be carried out. On the third season evaluation of the mash treatment on the yield and qualities of juice and pomace will be assayed. (Deliverable 1.2.6 and 1.2.7). The plant will be immobilized for two days in order to set up, isolate and control the pressing of 40 tons of apples, which will be divided in two homogenous lots. The first one will be PEF treated before squeezing, the second one not (control). All parameters of production will be noted, quantitative and specific yields of juice and dry pomace will be measured, adaptation of the juice to further processing (clarification, fermentation) will be evaluated. This trial will allow a complete technoco-economic assessment and

production of juice and pomace with and without insertion of a pretreatment of the apple mash. The juices will be bottled and stabilized for analyzing (Deliverable 1.2.6) and for presentation to retailers and consumers so that they can also estimate the expected improvement.

Feasability of sub-tasks 1.2.1 to 1.2.3 is high; risks are lack of impact of the technologies: PEF has been shown to increase juice yield (from beet) and US to enhance extraction of phytocomponents, but the conditions for efficient use may not be met during apple juice extraction (liquid / particle ratio for example).

WP 2 Characterisation of the products

The piority will be given to a comprehensive characterisation of the pilot scale products aiming specifically at the qualities of colour and texture, and at the pertinent nutritional properties, i.e. polyphenols, ascorbic acid and dietary fibers. Sampling will be carried out at key points of the process in addition to the raw material and the final products. Samples from laboratory scale trials and from modeling tasks 4.1 and 4.2 will be characterised using the same methods but with a more specific array. Standard determinations (sugars / acids, density, microbial load…) will also be carried out when deemed pertinent.

Task 2.1 Nutritional markers

The following analyses will be carried out on apples, on samples taken at various points during the processes to identify the most influent steps, and in final products:

- polyphenols: determination of specific polyphenols by HPLC-DAD with and without thioacidolysis (25); in the final products estimation of the presence and nature of oxidized polyphenols by HPLC-DAD-MSn (26), on samples from tasks 1.1 and 1.2.
- vitamin C differentiating ascorbic acid and its dehydro derivative by HPLC-UV and fluorimetry, and
- total and soluble dietary fibers by AOAC 991.43 on samples (including purees and chunks) from task 1.1.

This will be performed by P2 CTCPA for samples from task 1.1 (D2.1.1 and 2.1.2) and P3 URC for samples from task 1.2 (D2.1.3); estimation of oxidized polyphenols will be carried out at P3 URC. The samples will include for juices the juices and pomaces, for chunky apple desserts we will differentiate the chunks (collected by sieving with gentle washing), the puree particles (collected by centrifugation) and the serum (collected by centrifugation).

Task 2.2 Physical properties

Sub-task 2.2.1 Colour

Our aim is to establish the relationship between the sensory quality (colour, limpidity) of the juice or puree and polyphenol oxidation (including ascorbic acid and polyphenoloxidase activity) and non-enzymic browning. In the absence of heat treatment, browning will be a function of PPO activity, phenolic composition and conditions (temperature, pH). In juices these are the only parameters as no ascorbic acid is added in cider production and the juice is not heat-treated prior to fermentation. In fruit purees and desserts, additional factors are added ascorbic acid and the heat treatment. In addition to presence of residual PPO activity (itself a function of PPO thermoresistance, the presence of native phenols and the inhibitory effect of oxidized polyphenols), oxidation of ascorbic acid can be a first step towards non-enzymic browning.

Colour of processed products will be recorded in the CIE-L*a*b* uniform colour space using appropriate spectrophotometer / chromameters (by P1, P2, P3 and P7) (incorporated in D2.1.1 – 2.1.3).

To study the determinants of colour, P4 SCALE will use the polyphenol and vitamin C determinations of Task 2.1 and quantify PPO activity on fresh and liquid N_2-stabilised samples (D2.2.1). Residual PPO activity will be checked systematically in the raw material and in samples from the pilot plant trials (after grinding, after US or PEF treatments, in juices and fresh pomaces, after hot-break and in the apple chunks). These will be done both on the fresh samples by polarography for pilot plant experiments carried out at P3 URC and on samples preserved by freezing in liquid nitrogen for pilot plant experiments at P3 URC, P7 GPI, and P2 CTCPA. The PPO activity amounts and ratio of mono/diphenol oxidase activities will be checked at P4 SCALE using polarographic recording of oxygen consumption (27). In addition in chunky fruit dessert products, which will have been thermally treated, markers of sugar degradation (caramelization, Maillard reaction) will be quantified. Determination of 5-hydroxymethylfurfural, 2-furaldehyde and 2-furoic acid will be performed by HPLC-DAD (28) (D2.2.2).

Sub-task 2.2.2 Texture

The work carried out by P4 SCALE aims to establish the relationship between the “structure” of the fruit puree according to its different component - fraction of particles/serum, size and characteristic (shape, integrity) of particles, viscosity of the serum – and its rheological properties. The relationship with the sensory perception of texture and the influence of heat and mechanical treatment (particularly the effect on the cell walls and their components) will allow to manage the properties of the fruit puree as carrying phase.

The size distribution of the particles will be measured by laser granulometry. Microscopic observations will be also performed. Rheological properties of the purees will be determined as follow :
. flow properties on a large range of shear rate (coaxial cylinder viscometer)
. viscoelastic properties by dynamic measurement (coaxial cylinder or vane system - frequency sweep in linear domain)
. estimation of yield stress (vane method and/or limit of linear domain)
The flow and viscoelastic properties of the serum will be measured in the same way. If judged necessary, the viscosity of cloudy apple juices or musts from Task 1.2 will be assessed by the same methods.

Structure and rheology of the 4 initial purees (Sub-task 1.1.1), of reconstituted purees (Task 4.2) and of the carrying phases of subtask 1.1.2 before and after addition of chunks and the ohmic (or conventional) heat treatment will be determined (D2.2.4). Contrasted samples will be subjected to sensory analysis (Task 2.3) by a trained panel to establish a link between physical and sensory measurements.

Apple chunks after processing will be separated from their carrying phase as described in task 2.1. P1 SQPOV will assess the variation in their shape (image analysis) and texture by retro-extrusion using a texturometer (D2.2.6).
To study the determinants of the texture of the chunky fruit dessert, cell walls polysaccharides will be analyzed by P1 SQPOV in chunks, particles and serum, isolated as described in Task 2.1. The cell wall polysaccharides will be collected as alcohol insoluble solids as described in Renard (2005) and by ethanol precipitation from the serum and apple juice. The will be analyzed for sugar composition and methanol content. The soluble fraction will be extracted in gentle conditions (pH 3-4, 40°C) and analyzed for molecular weight distribution by SEC (D2.2.5).

Task 2.3 Sensory analysis

Sensory characterization of the juices and purees will allow to study the organoleptic impact of the various innovative processes under evaluation.

Sub-task 2.3.1 Juices

Juices from Task 1.2.3 (pilot scale trials; 6 to 10 juices, from PEF and US pretreatments plus control) will be assessed by a panel at PEIFL (Avignon) after 5 training sessions. They will be asked to rate colour, mouthfeel, presence of bitterness and astringency, and aroma (D2.3.1).

Sub-task 2.3.2 Purees and chunky fruit desserts

Sensory characterization of purees and chunky fruit desserts will be carried out by a trained panel from P5 GRAPPE. This group of 15 judges has an expertise on characterization of apples and apple purees. Specific training on texture of the carrying phase (puree) will be undertaken at the beginning of the work.
Two tasks have been planned:
First a characterization of the structure of the carrying phase (puree) in connection with its rheological measurements (Task 2.2.2 and 4.2). This step will allow to better understand the impact of formulation on the texture properties as perceived by consumers. About 30 products will be characterized; these products derive from the four purees of Task 1.1.2 by separation / regrinding of the particles / reconstitution as described in Task 4.2 (D2.3.2). This reconstitution approach and establishing a common experimental design between WP 4.2 and 2.3 will allow
- setting up a much wider variability (sensory and rheology) for understanding the impact of the various factors pre-identified as possibly contributing to texture (volumetric fraction and granulometry of the particles, viscosity of the serum);
- collecting data from this variability will give pertinent numbers for building up a model of the sensory characteristics as a function of the rheological measurements and experimental parameters. These data are a deliverable for WP 4.

After this first step, the trained panel will evaluate the chunky fruit desserts (12+3 products from WP 1.1 plus commercial equivalents) composed from carrying phases differing by their thickness and containing chunks of variable texture (D2.3.3). This will be used to establish the impact of ohmic heating and the interactions between the chunks and the carrying phase on organoleptic properties of the products. This characterization will also be related to the appreciation by “naïve” consumers planned in WP 3, and thus will allow to identify objectively the sensory characteristics appreciated or rejected by the consumers.

WP 3- Consumer's perception of innovation

The success of a new product on the market depends on several factors related in particular to acceptability by the consumers, the strategy of launching and the competitive context. (29). In addition, food product conveys many social and symbolic dimensions system that will influence the perception and the acceptability of an innovation in particular perceived benefits and perceived risk. Many researches showed that the innovating behaviour constitutes a feature characteristic of the individuals (30). The objective of this WP is to measure perception, acceptability and the global evaluation of a new product. We will also identify the individual variables that influence the innovating behaviour. In order to reach these aims we will use different methods: sensory methods, qualitative and quantitative surveys and the techniques of the experimental economy procedures (elicitation mechanism) (31).

Task 3.1 Consumer's taste appreciation

The processes and the formulations tested in Task 1.1.2 will lead to obtaining twenty products (15 from the project plus commercial equivalents) that are different in terms of colour, taste and texture. P5 GRAPPE will measure taste assessment on a sample of 480 non-experts consumers in order to draw their preference mapping. Results will lead to identify different operational variables of consumer appreciation that can be used to revise the formulation of the product. During this test we will ask for global evaluation of the product and also for quality and defaults of the twenty products tasted. These evaluations will be compared to the sensorial characteristics identified in WP 2.3, in order to highlight the most relevant characteristics for consumer's appreciation (D3.1).

Task 3.2 Product concept test

From these criteria, P6 MOISA will choose 4 concepts of products, which we will submit, to the consumers. For each concept, we will make an analysis of the value of the product for the consumer then a qualitative study near groups of consumers (3 groups) in order to validate the concept and to correct it if necessary.
Then we will undertake a quantitative study near 400 individuals relating to the following elements: clearness of the concept, originality, credibility, utility, product's characteristics, brakes and motivation in purchasing, conditions of use, problems of use, changes desired, the global evaluation and the intention of purchase. Acceptability and the attitude towards the new product as well as the personal variables, which influence product evaluation, will be also measured (D3.2).

Task 3.3 Information effect on product preference

As regards relevance of information that can influence consumer preference (nutritional information, sensory and technological information), P6 MOISA will design an experimental study that will make it possible to reveal the consumer's choices (32).
An evaluation of the willingness to pay (WTP) for each information will allow us to measure the contribution of each information to the global evaluation of the product. During this experimentation different tasks will be proposed to the consumer. (i) An evaluation of the product tasted without more information, (ii) without tasting but with nutritional information, (iii) with technological information only and finally (iv) complete information (taste, nutritional and technological information). 120 participants will compose the sample.
Statistical and econometric analysis will be used to determine each information value and the variables that influence the dependant variable (D3.3).

WP4 : Modelling the processing impact on the products

The number of pilot scale trials is limited because of the complexity of the issue. Modelling is an interesting way to limit those trials while making as much profit of the collected data as possible. Modeling will be carried out at different points and scales. Product/ process modelling is the main aim of the project: how to modulate the qualities by acting on the material and process variables. For this purpose, two points have been specifically identified as needing additional information:
- stability of the antioxidants, i.e. ascorbic acid and polyphenols: what are their reciprocal influence, what are the relative importance of enzymic / auto-oxidation; this includes a better understanding of the stability of PPO in complex systems.
- texture of purees: because this texture is still very poorly understood, we need first to relate the products characteristics to the sensory and rheological description of the global texture.

Task 4.1 – Anti-oxidants stability modelling

The aim of this task is to conduct trials with model systems in order to build up a stoechiokinetic model of coupled reactions of the antioxidants present in the fruit matrix. The reaction kinetics will be studied in vitro in

imitative systems (puree or juice) with increasing complexity. Two main factors will be considered: evolution of the antioxidants in the absence of PPO, as close as possible to a purely thermal system, and inactivation of PPO in complex systems. Indeed, much data has already been acquired / is currently being acquired on the generation of quinones by PPO (33-37) and the further evolution of these quinones, including reactivity with tannins and the formation of covalent links with cell walls (38, 39; 2 Ph.D. theses in STREP FLAVO and PI ISAfruit, respectively). Therefore, this work will not be repeated in the present project. Nevertheless, these data should be processed to reveal the underlying main reaction scheme attached with antioxydative properties of the food compound.

Subtask 4.1.1 Non-enzymic evolution of anti-oxidants

Kinetics of disappearance of the main polyphenols (chlorogenic acid, catechins and tannins) of apples and their interactions with ascorbic acid and cell walls will be studied at elevated temperatures (P2 CTCPA and P1 SQPOV). The composition variables will be cell walls, phenolic compounds and ascorbic acid, in conditions of pH and concentrations close to those of apple. Acidity and sugar content will be controlled. The reaction medium will be initially made of solutions of single components, after which the mixtures will then be complexified to end as a mix of all these components. The trials will be done with or without oxygen in order to dissociate thermal degradation from oxydative degradation of the compounds (D4.1.1 and .4).
Data which will be collected is disappearance of native polyphenols. It is not planned to study the structure of the reaction products but they will be compared to the products of enzymic oxidation.

Cell wall polysaccharides can affect the chemical reactions by specifically binding some compounds, through physico-chemical interactions and possibly also through covalent complexes cell walls – polyphenols, formed through quinones or carbocations. Reactions of cell walls with quinones will not be studied here as they are the aim of a Ph.D. work currently done in PI ISAfruit. Impact of the heat treatments on the capacity of cell walls do bind polyphenols, notably tannins, through non-covalent bonds, will be assessed by P1 SQPOV (D4.1.2 and .4).

Subtask 4.1.2 Inactivation of PPO

Impact of the presence of polyphenols, notably procyanidins, and of cell walls (apple particles) on the heat stability of apple PPO at a pH value close to that of apples will be assessed by P4 UMR SCALE. Kinetic parameters for PPO thermal denaturation will be determined for PPO extracted in particulate form from apple (40; from cultivars selected in WP1), heat-treated in the absence and in the presence of endogenous phenolic compounds (chlorogenic acid and flavan-3-ols) and in complex systems (apple juice and puree) (D4.1.3).

Sub-task 4.1.3 Model elaboration

A stoechiokinetic model will be built from the trial results, which will enable to forecast the behaviour of each component during the thermal treatment. It will allow the identification of the possible couplings between the degradation reactions of the compounds and their hierachisation in terms of kinetics and availability of reagents (e.g. O_2) (D4.1.6).
The model will be validated thanks to pilot trials with different temperature profiles. This step is very important as it will enable to obtain a predictive model depending on the mix composition and environment (temperature, acidity, sugar content), independent from the thermal transfer used, i.e. generic with regards to the process.

Task 4.2 – Puree rheology

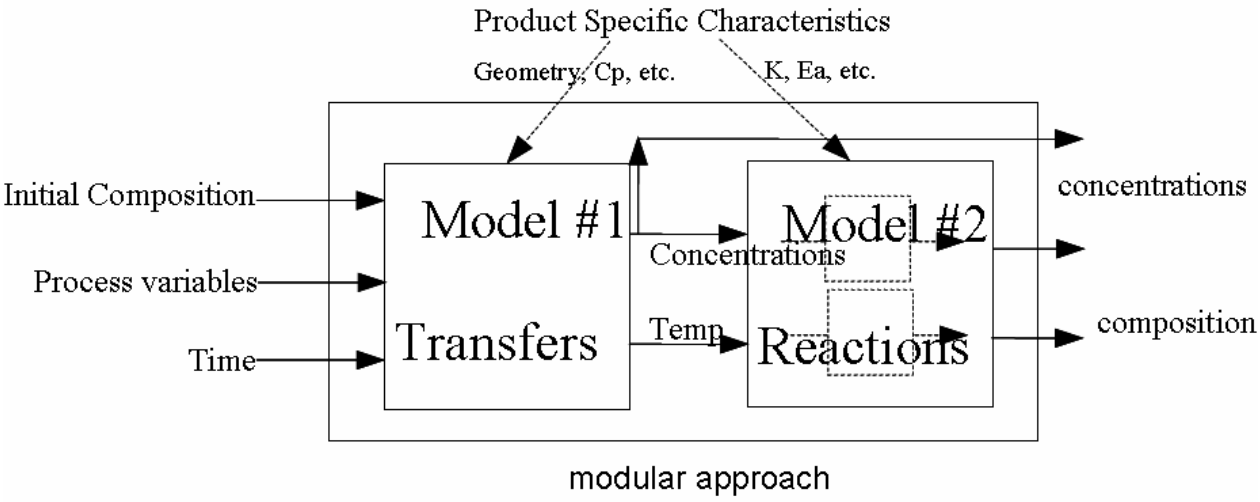
This corresponds to the exploitation of the data generated in Task 2.2 and its planification. Purees are suspensions of soft particles in a viscous liquid. Variables which have been identified as able to have an impact on puree texture are:

- volumetric fraction of particles / serum
- size (average and repartition) of the particles, and their shape factors
- viscosity of the serum.

In order to specify the impact of these three components, the purees prepared at Subtask 1.1.1 will be fractionated into particles and serum. The size distribution of the particles will be modified by grinding, sieving and controlled reconstitution of specific size profiles. These particles will then be remixed in varying proportions with serum, the viscosity of which might be modified by addition of thickeners (D2.2.3).
Rheology of the 4 initial purees and reconstituted purees will be determined as described in Subtask 2.2.2 (D4.2.1). Contrasted samples will be subjected to sensory analysis by a trained panel (Subtask 2.3.1) to establish a link between physical and sensory measurements (D4.2.2).
This will give a set of relations between the analytical characteristics of purees and their texture (analytical and sensory), which will be validated on the carrying phases of Sub-task 1.1.2. These characteristics will be measured before and after ohmic (and conventional) heating to identify the impact of the thermal treatment.

WP 4.3 product-process modelling

The logic of WP 4.3 is presented in the figure below:



To model the process influence on antioxydative characteristics of food compounds, a modular approach is prefered. Two different categories of models will be designed:

1. One comes from a reaction engineering approach and is meant to describe fairly the main reactions (with their couplings) necessary to predict the antioxydative power depending on local conditions (temperature, pH, O_2, etc.)
2. The other comes from a process engineering approach and is meant to describe precisely the heat and mass transfers, in the process, necessary to predict the local conditions depending on the process design and settings.

Each of these models, when validated on experimental data, will give a deliverable. The agglomeration of all into a global process-product-antioxydants model and its validation over a wide range of experimental conditions will be a major challenge and the final deliverable.
We will establish:
- the composition characteristics of the products before and after processing,
- the stoechiokinetic or diffusion constants of the evolution of the compounds of interest
- the history of the products during the process through the knowledge of the process variables, themselves used to calculated e.g. the time / temperature.

Depending on the nature and graininess of the available information, this can be integrated into product/process models. These models are then tested by trials specifically dedicated to check that the variables of influence have been identified and/or to identify lacks in the model.

Subtask 4.3.1 Thermal model

For the puree and fruit desserts the interest will be focussed on the heat treatment. The process operating conditions and the factor of dimensioning for the carrying phase and the thermal part will be determined in WP1.
The aim of the thermal model is to connect the histories (time-temperature) undergone by a fluid fraction and a solid particle during the process:
- the thermophysical and rheological properties of the mix when it enters the process (after identification of properties influencing the heating and the fate of reactive species constituting the mix)
- the main dimensioning parameters
- monitoring of the variables of the process (treatment in the heat exchanger for carrying phases, heat treatment in a ohmic unit for the carrying phase and the pieces)

To build the model we will need to establish the temperature and oxygen profiles within the different processes (and for the carrying phase and chunks) (D4.3.1). We will then use characterizations of WP 2 (rheology of carrying phase, nutritional markers analyses, carbohydrate degradation markers, residual PPO activity) and link them with known kinetic parameters (including activation energies), either from Tasks 4.1 and 4.2 or from pre-existing knowledge (D4.3.2).
These models should allow to predict the thermal history along the process.
Once these thermal models are validated and coupled with stoichiokinetics models developed in WP4, a simulation will permit to set the optimal operating conditions allowing a satisfying compromise of nutritional and organoleptic properties.

Sub-Task 4.3.2 Pulsed electrific field

The samples of apple tissue will be PEF treated allowing to control polarity and all protocol (E, t_{PEF}, t_p, Δt, T) and to measure electric conductivity and temperature in the course of the treatment. After treatment the samples will

be examined with LRC meter (up to frequencies of 10^6 Hz) and texture analyzer. The tissue damage degree will be estimated by comparison of electrophysical (disintegration index) and textural (module of mechanical strength, relaxation) tests. For dehydrated samples the porosity and rehydration capacity will be estimated by capillary impregnation and diffusion-conductometric methods, respectively. Theoretical and numerical calculations (with application of Monte Carlo and percolation models) are required in order to derive the optimal PEF protocols. The input parameters of these models will be derived from electrophysical experiments. The application of electronic microscopy allows to determine the level of PEF induced structure disintegration. The optimization of PEF assisted pressing (for fine selective juice extraction), and PEF enhanced diffusion requires mathematical simulation accounting for long term transient phenomena inside the apple tissue, as well as the tissue porosity and size of slices (D4.3.3).

Knowhow of the teams and organisation

Presentation of the teams and their specific interests

- UMR SQPOV has expertise in physical and biochemical analysis of fruits including pigments, chemistry of carotenoids and polyphenols; with the arrival of C. Renard and F. Chemat, its expertise now include characterization of polysaccharide/ polyphenol interactions and ultrasound and microwave assisted extraction of plant secondary metabolites; this project will be an occasion to integrate these new capabilities and enhance the work on processing in a concerted manner. The roles of UMR SQPOV will be methodology of US-assisted pressing, study of cell wall – polyphenol interactions and their modifications by heat treatment, characterization of chunky fruit dessert for colour, texture of chunks and cell wall components of chunks, particles and serums.
- CTCPA, French technical centre for the food industry, provides support and contributes to the development of companies of the agro-food industry. It focuses on three topics: innovation (product / process / packaging), productivity and food safety. It has developed methods for nutritional analysis of processed fruits and vegetables and participates in NovelQ for technico-economic of evaluation of ohmic heating; CTCPA and SQPOV have recently set up a cooperation agreement on measurement and validation of nutritional qualities of processed fruits and vegetables, to which the present project participates. It will produce purees and chunky frit desserts, carry out nutritional evaluation and participate in building of models for stability of polyphenols and vitamin C.
- URC has experience in characterization of native and oxidised polyphenols, notably of apples: quantification and structural characterization, using dedicated LC-MS instrumentation. INRA-URC have worked on production of juices and nectars by maceration, and innovative methods for stabilisation of cloudy apple juice (FAIR CT96-1113). Apples and their transformation to cider are at the core of URC expertise. URC will participate in study of US- and PEF-assisted apple pressing at the pilot scale and by characterization of the composition and characteristics of the juices. It will analyse native and oxidised polyphenols and PPO activities.
- UMR SCALE aims to understand reaction mechanisms and consequences in food processing. Two of its majors subjects are structuration and properties of food materials, with expertise in biophysics of food macromolecules, and study of oxidative processes in foods. This project will allow SCALE to build-up on existing expertise for a more integrated and product-oriented approach. SCALE will analyse the texture of apple purees and carrying phases and decompose these composite systems to undesrtand their rheology. It will also analyse residual PPO activity and inactivation in food matrix, and identify markers of heat-degradation of sugars.
- The laboratory GRAPPE has set up a recognised sensory analysis laboratory with specialisation in texture analysis of fruits (apple) and fruit products (juices, purees, wine); it also develops biochemical and biophysical methods for analysis of apple fruits. This project will use and develop the experience of the group in studying the relation between physical and sensory texture descriptors. GRAPPE will organise the preference mapping on the chunky fruit purees, in cooperation with the consumer and marketing approach of UMR MOISA
- The MOISA (Markets, Organisations, Institutions and Operators' Strategies) Research Unit is a public research laboratory working in the field of social sciences (economics, management, socio-anthropology). Research falls under the umbrella of a programme entitled "Coordination Measures and Operators' Strategies in agricultural, food-processing and rural systems". Analysis of determinants of food consumer's behaviour is at the heart of the UMR research program. UMR MOISA will carry out background questionnaires, experimental economics and study group evaluations of innovation in the food processing industry.
- The expertise of UMR GPI concern the control and elaboration of complex heterogeneous systems, taking into account notably the transport phenomena at different scales. GPI has developed and patented processes using Pulsed Electric fields for extraction of plant materials. This project will allow GPI to integrate fine biochemical impact of the PEF and validate the concept at full industrial scale. GPI will carry out laboratory scale experiments for off-line methodological studies on PEF response of apple tissues, pilot plant experiments on apple pressing and act in advisory manner for industrial scale trials.
- Val-de-Vire SAS is the second cider producer in France, with three plants in Brittany and Normandy. It is an affiliate of Elle-et-Vire cooperative and produces soft and fermented drinks from apples. Its interests are controlling colour through transfer and oxidation of phenolics in juices and pomaces, improvement of sugars recovery, limiting volumes of juices to be concentrated and humidity of pomaces to be dried, reduction of microbial load for a more standardised fermentation substrate, having a possibility to modulate pressing according to apples variety and maturity.

- UMR-GENIAL will provide guidance and assistance in all experiment planning and analysis when related to modelling (stoechiokinetics). UMR-GENIAL will also build up the heat and mass transfer model of an ohmic heater with the help of a postdoc fellow. Both models (quality based and transfer based) should then be merged in a powerful simulation tool.
- REUS devises and produces equipments for US-assisted extraction from plant material and conceives their insertions in complete production chains (30 installations in Italy to date). The planned work is an extension of its expertise. REUS will produce a power ultrasound pilot for the project and advise on use in pressing chains.
- Héro-France, producer of purees and compotes for 30 years, can bring to the project its experience, its R&D and industrial capacities, its knowledge of the raw material. Beyond a validation of the nutritional qualities of processed apple products, its specific interest is in the evaluation of puree texture. It will participate by providing contrasted material and take part in evaluation of the new products.

Materials and infrastructures

The partners of the consortium have most facilities for carrying out the processes and characterizations:
- pilot plants for production of purees and ohmic heating (P2 CTCPA), PEF at the laboratory and pilot scale (P7 GPI), power US treatments at the laboratory scale, and pressing of apple at scales from 1-3 kg (instrumented), 15-100 kg (and appx 1T) at P3 URC.
- analysis methods : biochemical (P1 SQPOV, P2 CTCPA, P3 URC, P4 SCALE) and physical (rheology P4 SCALE), colour and texture (P1 SQPOV));
- sensory analysis (P5 GRAPPE) with expertise on texture characterization, and consumer studies (P5 GRAPPE, P6 MOISA)
- modelisation of processes (P8 GENIAL) and reactions (P1 SQPOV, P8 GENIAL).
We have planned within the project the elaboration of a pilot power US equipement, by a specialised partner (P10 REUS). Full size industrial validation is panned for juice extraction with partner 9 Val-de-Vire.

Consortium organisation

The academic teams have been chosen because their strong points are complementary and can lead to crystallisation of an integrated multidisciplinary group with state-of-the-art capabilities from modelisation (P8 GeniAL, P7 GPI) through process engineering (P7 GPI, P1 SQPOV, P2 CTCPA), rheology (P4 SCALE), biochemical analysis of the compounds of interest (P1 SQPOV, P3 URC, P4 SCALE, P2 CTCPA), to sensory analysis and consumer studies (P5 GRAPPE, P6 MOISA). Most are familiar with the product (apple) being processed and share a common vision of excellence in goal-oriented research.

Deliverables are
- products from WP1, for analysis in WP 2 and WP 3;
- analytical data from WP 2 for inclusion in and validation of models elaborated in WP 4;

The project is organised in two streams (juice and fruit dessert) which converge in the analysis of polyphenols and their reactivity. All WPs are transversal for mutual exchange of ideas and methods. Scientific management will provide the connections between observations on each model and the questions raised by the modelling approach. Three Ph.D. theses are planned to take place within the framework of the project:
- one (P1 SQPOV) on the methodology of US-assisted extraction ; application of this work to apple processing will involve close cooperation with and pilot place trials at P3 URC.
- the second is planned to be co-tutored by P7 GPI and P3 URC and work on the quantitative (energy, yield, process variables) and qualitative (polyphenol and pectin extraction, PPO activity) aspects of PEF-assisted pressing. Funding is asked from ADEME and this project.
- the third will be recruited by P11 Héro-France for a Ph.D. (CIFRE) tutored by P4 SCALE in cooperation with P2 CTCPA (production of chunky fruit puree) and P5 GRAPPE (sensory analysis) and aiming at understanding the relation between physical and sensory description of apple texture.
The project coordinator will participate to the theses' comittees to ensure that full advantage is being taken of potential advances by other partners.

A piloting committee will be established as stated in the projected consortium agreement; it will meet twice a year and further be consulted e.g. on intellectual property right issues, publication plans and deviations from the work plan. Due to potential industrial applications of the project, we will not set-up a public oriented web-site.

DESCRIPTION DES EQUIPES / IDENTIFICATION OF THE COORDINATOR AND OF THE OTHER PARTNERS

4.1P - TEMPANTIOX

Partner 1 (coordinator) one coordinator must be chosen by the partners to be the scientific leader of the project

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Coordinateur/ Coordinator	RENARD	Catherine	DR	INRA	9	Coordinator ; study of interactions between polyphenols and other constituents of the plant matrix ; impact of heating on polysaccharides
Membre /Member	CHEMAT	Farid	PR	Université d'Avignon	9	Ultrasound extraction methods – process engineering
Membre /Member	TOMAO	Valérie	MC	Université d'Avignon	6	Assement of impact of US extraction methods (yields of specific components)
Membre /Member	VIROT	Matthiew	Ph.D.	Université d'Avignon	12	Ultrasound extraction methodology
Membre /Member	XX (to be recruited – 2007)		CR	INRA	12	Physico-chemical interactions between polyphenols and cell walls
Membre /Member	MAINGONNAT	Jean-François	DR2	INRA	3	Analysis of processed products – physical characteristics
Membre /Member	REGIS	Sylviane	IE2 (60%)	INRA	14	Analysis of colour and general characteristics of processed products Isolation of polyphenols (tannins) and cell walls - characterization
Membre /Member	GINIES	Christian	AI	INRA	6	Analysis of cell walls
Membre /Member	BOGE	Marielle	AJT	INRA	3	Management of samples
….						
		TOTAL	**personnel (Permanent**	**Permanent staff)**	74	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		

Temporary mission	XX	XX	Student (training period)	2	5	Interaction of polyphenols with heat-degraded polysaccharides
Temporary mission	XX	XX	Student (training period)	3	5	To be defind depending on project advancement
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	10	
		TOTAL	**GENERAL**	**Personnel (staff)**	84	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

Joindre un CV du coordinateur (Maximum 2 pages) / Join a curriculum vitae of the coordinator of the project (CV maximum 2 pages)

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 1: UMR SQPOV

Chemat F. & Hoarau N. (2004) Hazard analysis and critical control point in ultrasound food processing operations. *Ultrasonics Sonochemistry* 11: 257-260.

Chemat F., Lucchesi M.E., Smadja J., Faveretto L., Colnaghi G. & Visioni F. (2006) Microwave accelerated steam distillation of essential oil from lavender: rapide, clean and environmentally friendly approach. *Analytica Chimica Acta* 555: 157-160.

Le Bourvellec C., & Renard C.M.G.C. (2005) Non-covalent interactions between procyanidins and apple cell wall material. Part II : quantification and impact of cell wall drying. *Biochim. Biophys. Acta* 1675 1-9

Le Bourvellec C., Le Quere J.-M., Guyot S., Baron A. & Renard C.M.G.C. : Le rôle des parois végétales dans le transfert des tannins du fruit au jus : exemple de la pomme. *Ind. Alim. Agric*. 123 (2007) 9-17

Renard C.M.G.C. (2005) Effects of conventional boiling on the polyphenols and cell walls of pears. *J. Sci. Food Agric.* 85 (2005) 310-318

4.1P - TEMPANTIOX

Partner 2 CTCPA

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	GEORGÉ	Stéphane	Project manager – senior researcher	CTCPA	3,43	In charge of the project management and the analytic issues
Membre /Member	FINE	Frédéric	Junior researcher	CTCPA	1,14	In charge of the technological issues
Membre /Member	Technicien biochimie		Lab technician	CTCPA	5	In charge of the analysis realisation
Membre /Member	AUPY	Fabien	Technologist technician	CTCPA	3,17	In charge of the technological trials realisation
		TOTAL	**personnel (Permanent**	**Permanent staff)**	12,7’	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	(If known)	(If known)				
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**		
		TOTAL	**GENERAL**	**Personnel (staff)**	12,74	

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 2 : CTCPA

Beney L., Perrier-Cornet J.-M., Fine F., Gervais P. 2003. Combining thermal and other preservation techniques. Woodhead Publishing Ltd., Ed. Peter Zeuthen and Leif Bogh-Sorensen. /Food Preservation Techniques/, 179-203.

Brat P, Georgé S, Bellamy A, Du Chaffaut L, Scalbert A, Mennen L, Arnault N and Amiot M-J. Daily polyphenol intake in France from fruit and vegetables. *J Nutr*, 2006; 136:2368-2373.

Fine, F., and P. Gervais. 2004. Evaluation of pulsed UV light efficiency for microbial decontamination of food powders. Journal of Food Protection. 67(4):787-792.

Georgé S, Brat P, Alter P and Amiot M-J. Rapid determination of polyphenols and vitamin C in plant derived products. *J. Agric. Food Chem*. 2005, 53: 1370-1373.

Georgé S, Courtois F, Trystram G, Amiot M.J. Impact of technological process on the nutritional value of apple purees Communication orale au Colloque international sur la transformation de la pomme 15 Mars 2005 – Rennes, FR

4.1P - TEMPANTIOX

Partner 3 URC

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	BARON	Alain	CR	INRA	4	Project management ; study of mash modification induced by PEF or US treatments (texture, enzyme activity)
Membre /Member	GUYOT	Sylvain	CR	INRA	6	Oxidised phenolic compounds analysis (LC-MS)
Membre /Member	LE QUERE	Jean-Michel	IR1	INRA	5	Head of pilot plant at URC ; process modelling
	MARNET	Nathalie	AI	INRA	6	In charge of the analysis of native polyphenols (HPLC)
	GESTIN	Patrick	TRS	INRA	2	Pilot plant technician
	LE MARRE	Nathalie	TRN	INRA	2	Administrative staff
	GACEL	Agnès	AJT	INRA	7	Biochemical analysis of apple, mash, pomace and juices
	LE BAIL	Gildas	AJT	INRA	3	Apple and juice processing
		TOTAL	**personnel (Permanent**	**Permanent staff)**	36	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Ph.D. student (50% cofinanced)	XX	XX	M2	1	36	Study on PEF treatment on apple mash (codirected with partner 7)
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	36	
		TOTAL	**GENERAL**	**Personnel (staff)**	72	

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 3 : URC

Guyot, S., Serrand, S., Le Quéré, J. M., Sanoner, P. & Renard, C. M. G. C. (2007) Enzymatic synthesis and physicochemical characterisation of Phloridzin Oxidation Products (POP), a new water-soluble yellow dye deriving from apple. *Innovative Food Science and Emerging Technologies*, in press.

Guillermin, P.; Dupont, N.; Le Morvan, C.; Le Quéré, J.-M.; Langlais, C.; Mauget, J. C. (2006). Rheological and technological properties of two cider apple cultivars. *Lebenmittel-Wissenschaft und Technologie*, 39, 995-1000.

Baron, A.; Denes, J. M.; Durier, C. (2006).High-pressure treatment of cloudy apple juice. *Lebensmittel-Wissenchaft und Technologie*, 39, 1005-1013.

Le Bourvellec, C.; Le Quéré, J. M.; Sanoner, P.; Drilleau, J. F.; Guyot, S. (2004).Inhibition of apple polyphenol oxidase activity by procyanidins and polyphenol oxidation products. *Journal of Agricultural and Food Chemistry*, 52, 122-130.

Bernillon, S.; Guyot, S.; Renard, C. M. G. C. (2004).Detection of phenolic oxidation products in cider apple juice by HPLC electrospray ionisation ion trap mass spectrometry. *Rapid Communications in Mass Spectrometry*, 18, 939-943.

4.1P - TEMPANTIOX

Partner 4 : UMR SCALE

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	CUVELIER	Gérard	PR	AgroParisTech MAP	5	Study of texture of fruit purees.; rheological properties - structure relationships ; Impact of technological treatments.
Membre /Member	BILLAUD	Catherine	IR2	CNAM	6	study of inactivation of PPO and markers of heat-degradation
Membre /Member	MAILLARD	Marie-Noëlle	MC	AgroParisTech MAP	2	Analytical methodology
Membre /Member	GRANDA	Pablo	AI	AgroParisTech MAP	4	Rheological measurements.
Membre /Member	GIBON	Anne-Marie	AJT	AgroParisTech MAP	5	Management of samples
		TOTAL	**personnel (Permanent**	**Permanent staff)**	22	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	XX	XX	student (training period)		9	study of inactivation of PPO and markers of heat-degradation
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	9	
		TOTAL	**GENERAL**	**Personnel (staff)**	31	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 4: UMR SCALE

Billaud C., Maraschin C., Nicolas J. (2004). Inhibition of polyphenoloxidase from apple by Maillard reaction products prepared from glucose or fructose with L-cysteine under various conditions of pH and temperature. Lebensm. Wissen. Technol., (37), 69-78.

Michon C., Chapuis C., Langendorff V., Boulenguer P., Cuvelier G. (2005). Structuration of carrageenan/milk gels studied by rheology: effect of shearing, carrageenan concentration and nu fraction. Food Hydrocolloids, 19, 541-547.

Michon C., Chapuis C., Langendorff V., Boulenguer P., Cuvelier G. (2004). Strain-hardening properties of physical weak gels of biopolymers. Food Hydrocolloids, 18, 999-1005.

Balerin, C., Aymar, P., Ducept, F., Vaslin, S. & Cuvelier G (2007). Effect of formulation and processing factors on the properties of liquid food foams. J. Food Eng. 78, 802-809

Chériot S., Billaud C., Maillard M.N., Nicolas J. (2007). Inhibition of polyphenoloxidase activity by mixtures of heated cysteine derivatives with carbonyl compounds. *Mol. Nutr. Food Res.*, **51**, 395-403.

4.1P - TEMPANTIOX

Partner 5 GRAPPE

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	SYMONEAUX	Ronan	Project manager – Ingénieur	ESA	1,66	In charge of the project management and the analytic issues
Membre /Member	JOURJON	Frédérique	DR	ESA	0,27	In charge of the analytic issues
Membre /Member	MEHINAGIC	Emira	DR	ESA	0,83	In charge of the analytic issues
Membre /Member	Technicien Sensoriel		Technicien	ESA	8,38	In charge of sensory test and consumer test realisation
Membre /Member	PANEL POMME		Cadre	ESA	3	In charge of sensory test realisation
Membre /Member	PANEL POMME		Non Cadre	ESA	2,66	In charge of sensory test realisation
		TOTAL	**personnel (Permanent**	**Permanent staff)**	16,8	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission Ingénieur senso CDD			MSC	2009	3,83	In charge of consumer test realisation
Stagiaire			MSC	2009	12	In charge of consumer test realisation
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	15,83	
		TOTAL	**GENERAL**	**Personnel (staff)**	32,63	

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

JOURJON F, SYMONEAUX R., THIBAULT C., REVEILLERE M., (2005) Comparaison d'échelles de notation utilisées lors de l'évaluation sensorielle de vins. Journal International des sciences de la Vigne et du vin, , 39, 1,23-29

MEHINAGIC E., ROYER G., SYMONEAUX R., BERTRAND D., JOURJON F. (2004) Prediction of the sensory quality of apples by physical measurements. Postharvest Biology and Technology, , 34, 257-269.

ROYER G., MADIETA E., SYMONEAUX R., JOURJON F. (2006) Preliminary study of the production of apple pomace and quince jelly. Lebensmittel-Wissenschaft und –Technologie, , 39, 1022-1025.

SYMONEAUX R., REVEILLERE M., DANARD A.M., JOURJON F. (2004) Utilisation de l'analyse textuelle pour la compréhension des préférences lors d'un test hédonique sur les pommes. Agrostat, Rennes

SYMONEAUX R., BAUDENAN P., JOURJON F. (2004) Consumer preference mapping of white wines from different geographic origins of Vallée de la Loire. A sense of Identity : European conference on sensory sciences of food and beverages, Septembre Florence

4.1P - TEMPANTIOX

Partner 6 UMR MOISA

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	FORT	Fatiha	MCF	Montpellier SupAgro	6	WP3: Perception du consommateur
Membre /Member	Padilla	Martine	EC	CIHEAM-IAM	2	
Membre /Member						
….						
		TOTAL	**personnel (Permanent**	**Permanent staff)**	8	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	(If known)	(If known)	Ingénieur	Année 1	3	
Temporary mission	(If known)	(If known)	assistant	Année 3	5	
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	8	
		TOTAL	**GENERAL**	**Personnel (staff)**	16	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 6 UMR MOISA

Aurier Ph., Fort F., (2007), The effect of perceived congruity between origin, brand, and product on the purchase intention of a branded product of origin, Advances in Consumer Research, vol. 34, A paraître.

Fort F., Fort F., (2006), Diminuer les risques d'échec lors de la mise en oeuvre des «changements packagés» une approche culturaliste appliquée à l'introduction d'un TQM, Revue Française de Gestion, 51-68.

Aurier Ph., Fort F., (2005), Effets de la région d'origine, du produit, de la marque et de leurs congruences, sur l'évaluation des consommateurs : application aux produits alimentaires, Recherche et Applications en Marketing, Vol 20, 4, 29-52.

Fort F., Fort F., (2005), « Alternatives marketing pour les produits de terroir : éléments de réflexion et voies de recherche », Revue Française de Gestion, N° 166, 51-68.

Aurier Ph., Fort F., Sirieix L., (2005), « Exploring terroir meanings for the consumer", Anthropology Of Food, issue 04, mai.

4.1P - TEMPANTIOX

Partner 7 GPI

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	VOROBIEV	Eugène	PR	Université de Technologie de Compiègne (UTC)	6	Project management, PEF extraction – process engineering
Membre /Member	LANOISELLE	Jean-Louis	MC	UTC	6	Impact of PEF on the physico -chemical and textural properties of products
Membre /Member	NONUS	Maurice	IR1	UTC	6	Impact of PEF on the colour and general characteristics of processed products
….						
		TOTAL	**personnel (Permanent**	**Permanent staff)**	18	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	LEBOVKA	Nikolai	Post-doc	1	9	Impact of PEF on the electro-physical properties of products, modelisation of electroporation
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	9	
		TOTAL	**GENERAL**	**Personnel (staff)**	27	

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partenaire 7 UMR GPI

Praporscic I., Shynkaryk M., Lebovka N.I., Vorobiev E. Analysis of juice colour and dry matter content during pulsed electric field enhanced expression of soft plant tissues,. *Journal of Food Engineering*, 2007, 80 (2), p. 639-644.

Amami E., Vorobiev E., Kechaou N. Modelling of mass transfer during osmotic dehydration of apple tissue pre-treated by pulsed electric field, *LWT- Food Science and Technology*, 2006, 39 (9), p.1014-1021.

Lebovka N.I., Praporscic I., Vorobiev E. Combined treatment of apples by pulsed electric fields and by heating at moderate temperature, *Journal of Food Engineering*, *2004*, 65, p.211-217.

Jemai A.B., Vorobiev E. Effect of moderate electric field pulses on the diffusion coefficient of soluble substances from apple slices. *International Journal of Food Science and Technology*, 2001, 37, p.73-86.

Bazhal M., Vorobiev E. Electrical treatment of apple cossettes for intensifying juice pressing, J. *Sci. Food Agric.*, 2000, 80, p. 1668-1674

4.1P - TEMPANTIOX

Partner 8 UMR-GENIAL

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	Courtois	Francis	Dr/Ing/MC	UMR GENIAL	4	WP4 Design of experiments for modelling. Modelling of stoechiokinetics. Modelling of ohmic heating.
Membre /Member	Broyart	Bertrand	Dr/Ing/MC	UMR GENIAL	2	WP4 . Modelling of stoechiokinetics. Modelling of ohmic heating
Membre /Member						
….						
		TOTAL	**personnel (Permanent**	**Permanent staff)**	6	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	X	X	postdoc	2 or 3	6	WP4 Modelling of ohmic heating
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	6	
		TOTAL	**GENERAL**	**Personnel (staff)**	12	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

Principales publications ou brevets du partenaire (Maximum 5 publications sur les 5 dernières années relatives au domaine de la proposition de projet) / Main publications or patents of the partner (5 max publications of the last 5 years, and relevant to the research field of the application)

Partner 8 UMR-GENIAL

BROYART, B., TRYSTRAM, G. 2003. Modeling of heat and mass transfer phenomena and quality changes during continuous biscuit baking using both deductive and inductive (neural network) modelling. *Foods and Bioproducts Processing: Transactions of the Institution of Chemical Engineers Part C.* Volume 81 Number C4, p 316-326.

COURTOIS, F., ABUD ARCHILA, M., BONAZZI, C., MEOT, J.M., TRYSTRAM, G. 2001. "Modeling and control of a mixed-flow rice dryer with emphasis on breakage quality", Journal of Food Engineering, 49, pp. 303-309.

ABUD ARCHILA, M., BONAZZI, C., COURTOIS, F., BIMBENET, J.J. 2000. "Processing quality of rough rice during drying - modelling of head rice yield versus moisture gradients and kernel temperature", Journal of Food Engineering, 45, pp. 161-169.

TRYSTRAM, G., TRELEA, I.C.,RAOULT WACK, A.L., DIAZ, A., COURTOIS, F. 1999. Indirect measurement and control of moisture content during dehydration performed by frying, Drying Technology, 17 (7&8), 1627-1637.

TRELEA, I.C., COURTOIS, F., TRYSTRAM, G., 1997, Dynamic models for drying and wet-milling quality degradation of corn using neural networks, Drying technology, 15(3), pp. 1095-1102.

4.1P - TEMPANTIOX

Partner 9 VAL DE VIRE SAS

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	CHAMERET	Raynald	Directeur Industriel (Manager Manufacturer)	VAL DE VIRE SAS	0,4	Gestion Planing of trials, mesures and derivation of production flows
Membre /Member	LEPILEUR	Didier	Responsable Fabrication (Product Manager)	VAL DE VIRE SAS	0,3	Practical organisation of trials
Membre /Member	VOISIN	Olivier	Responsable Maintenance (Maintenance Manager)	VAL DE VIRE SAS	0,3	Practical organisation of trials
Membre /Member			Opérateurs pressage (Cider press Operators)	VAL DE VIRE SAS	0,4	Practical organisation of trials
Membre /Member			Opérateurs traitement des jus (Cellarmen)	VAL DE VIRE SAS	0,4	Practical organisation of trials
Membre /Member			Opérateurs embouteillage (Conditioning Operators)	VAL DE VIRE SAS	0,4	Practical organisation of trials
Membre /Member	SANONER	Philippe	Ingénieur (Engineer)	VAL DE VIRE SAS	0,2	Execution of Trials 1 and 2, sampling and analysis
Membre /Member	MURIS	Sophie	Technicienne laboratoire (Laboratory Technician)	VAL DE VIRE SAS	0,3	Execution of Trials 1 and 2, sampling and analysis
		TOTAL	**personnel (Permanent**	**Permanent staff)**	**2,7**	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)	/	
Temporary mission	/	/	/	/	/	
		TOTAL	**Personnel (temporary**	**Temporaire staff)**	/	
		TOTAL	**GENERAL**	**Personnel (staff)**	**2,7**	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

4.1P - TEMPANTIOX

Partner 10 REUS

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	GANTZ	Charles	Ingénieur	REUS	4	Conception and elaboration of ultrasound pilot
Membre /Member						
Membre /Member						
….						
		TOTAL	**personnel (Permanent**	**Permanent staff)**		
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	(If known)	(If known)				
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**		
		TOTAL	**GENERAL**	**Personnel (staff)**	4	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

4.1P - TEMPANTIOX

Partner 11 Héro France

Personnel permanent et personnel temporaire non financé par le projet (permanent staff and temporary staff not financed by project)	Nom/Surname	Prénom/Forename	Title/grade / Emploi (Job)	Organisation/ firm	Nombre de mois homme / Man.month (*)	Rôle dans le projet /Responsibilities in the project (maximum 4 lines)
Responsable scientifique/ Main scientist	SABLAYROLLES	Jean-Louis	Directeur R&D qualité	Héro France	1	Supervision and participation to the elaboration of the Ph.D. project
Membre /Member	DRUART	Cécile	Responsable R&D	Héro France	2	Supervision of the Ph.D. student – organisation of specific puree preparation – partipation to meetings
Membre /Member	To be recruites		Ph.D. student	Héro France	36	CIFRE thesis – realisation of trials (puree texture and impact of time/temperature)
Membre /Member	Techniciens			Héro France	6	Production of puree and standard characterization
		TOTAL	**personnel (Permanent**	**Permanent staff)**	45	
Personnel temporaire à recruter sur le projet (temporary staff to be financed)	Nom/Surname	Prénom/Forename	Niveau de recrutement pour CDD (Recruitment level)	Année de recrutement pour CDD (year of the beginning of the contract)		
Temporary mission	(If known)	(If known)				
Temporary mission	(If known)	(If known)				
		TOTAL	**Personnel (temporary**	**Temporaire staff)**		
		TOTAL	**GENERAL**	**Personnel (staff)**	45	

(*) Nombre de mois dédié au projet pendant la durée du projet / number of months dedicated to the project during the course of the project

GANTT CHART

	Hommes-mois du partenaire / partners'personsmonth												Durée / chemin critique
													Année 1/ year 1	Année 2/ year 2	Année 3/ year 3
	1	2	3	4	5	6	7	8	9	10	11	**Total**	1 6 12	1 6 12	1 6 12
WP 1 Use of emerging technologies															
Task 1.1 Chunky fruit dessert		3,9									10	**13,9**			
Task 1.2 High quality juices	18		32				12		2,7	4		**68,7**	Laboratory scale/table apples		
WP 2 Characterization of the products															
Task 2.1 Nutritional markers	12,5	3	13									**28,5**			
Task 2.2 Physical properties	16		9	18							16	**59**			
Task 2.3 Sensory characterization				1	10,7						7	**18,7**			
WP 3 Consumer's perception of innovation															
Task 3.1 Taste appreciation					21,9							**21,9**			
Task 3.2 Concept test						8						**8**			
Task 3.3 Information effect on preference						8						**8**			
WP 4 Modeling the processing impact															
Task 4.1 Anti-oxidants stability	26	3		3								**32**			
Task 4.2 Puree texture				3							6	**9**			
Task 4.3 Product / process modeling	4	1,25	12				15	12			3	**47,25**			
Management	3		2									**5**			
Total	**79,5**	**11,2**	**68**	**25**	**32,6**	**16**	**27**	**12**	**2,7**	**4**	**42**	**319,95**	☺ ☺ ☺	☺ ☺	☺ ☺
In year 1	28,5	4	27	9	0,24	5	12	2	0,25	3	13,5	**104,49**			
In year 2	31	5,4	26	17	8,2	5	9	4	0,25	0,5	15	**121,35**			
In year 3	17	1,75	15	8	24,1	6	6	6	2	0,5	13,5	**99,85**			

☺ Meetings and reports

5 - RESULTATS ESCOMPTES – PERSPECTIVES /*EXPECTED RESULTS*

Direct expected scientific results are of two types : balances (fate of polyphenols, of cell wall polysaccharides, componants of texture as a function of the history of the product, yields) and mechanisms (identification and relative importance). We believe that we will be able to establish relations between the history of the products and the fate of polyphenols, taking into account in an integrative manner enzymatic oxidation, autooxidation and thermal degradation. We should understand better the role of cell walls in diffusion of polyphenols. We expect significant advances in understanding the texture of suspensions of soft particles, linking the perception and rheological/physical measurements of their texture, and maybe even the modifications of cell wall polysaccharides. We should have indications on the perception of these composite suspensions and the key points for the consumer. Lastly, we should gain some knowledge on emotional perception of innovation in agri-food chain and its impact on buying.

For practical applications, these results should contribute to identify the nutritional qualities of processed fruits and vegetables. Specifically for juices the project will be successful if we demonstrate that a physical pre-treatment of apple mash increases significantly juice yields while decreasing energy use. This juice should be suitable for further processing into direct juice (limited microbial load, attractive colour, ease of clarification or stabilisation of cloud) or cider (suitable N content, high density, establishment of anaerobic conditions), eventually with adaptations of the technology such as pitching of selected yeasts. The pomace should be suitable for further extraction of polysaccharides (pectins) and phenolics. For chunky fruit desserts we expect to describe a process, and hope to propose a production chain including the emerging technologies under evaluation which is clean, energy-efficient and safe, and delivers a superior product (nutritional density, attractivity). Additionaly we could have guideline for its adaptation to produce a series of related products, have identification of consumers expectations and partitioning, and a tentative marketing approach.

On the organisational point of view, a major factor will be cross-fertilisation and efficiency of the cooperation between the different groups. Three Ph.D. students will be involved in the project: for two of them the project will be an application of more methodological studies on emerging technologies, while for the third one the project will directly include understanding texture of soft particle suspensions. All of these theses imply co-tutoring or at least carrying out part of the experimental work at another team. This will be a strong integration factor. The completion of the theses and their quality (examination, number of publications) will be an indicator, as will be co-publications between the involved teams, together with further joint participations in further projects. We plan to organise at the end of the project a second occurrence of the symposium on apple processing which had been organised in March 2005 in Rennes.

Understanding the mechanisms of polyphenols and ascorbic acid disappearance in processed products will allow proposing guidelines for their preservation in the processing chain. These will have to be validated and adapted to the various plant matrixes. A better knowledge of the physical and sensory determinants of apple sauce texture is a first step for understanding the relationship between the apple and puree characteristics (cultivar and physiological state against texture and colour of final product). Both of these points need to be taken into account for exploring the suitability of plant material for processing and processing-directed selection and adaptation of technical itineraries. Other scientific perspectives are on the one hand a study of the newly formed polyphenols and/or adducts, notably determination of the colour / structure relationships. More detail work would be needed to understand the mode of action of PEF and US at the sub-cellular level. Perspectives also include bioavailability studies on the processed products if we have shown marked differences in concentrations and diffusibility of the phenolics.

Tableau de synthèse des livrables et des jalons (voir modèle ci- joint)

TABLEAU DE SYNTHESE des LIVRABLES et des JALONS (Synthetic table of the deliverables and milestones)			
Tâche (Task)	Intitulé et nature des livrables et des jalons (deliverables and milestones)	Date de fourniture ***nombre de mois à compter de T0*** ***Calendar*** ***(month of delivery T0)***	Partenaire responsable du livrable/jalon (Partner in charge)
1. WP 1 Use of innovative technologies for processing apples			
	D1.1.1 – Apples selected for preparation of purees sent to P1 for characterization	3	P2
	D1.1.2 – Purees (4 samples of contrasted texture) in 1/1 cans sent to P1 and P4	6	P2
	D1.1.3 – Data on process variables sent to P8	9	P2
	D1.1.4 – Purees (3 samples of contrasted texture, 3T each in 150kg aseptic packaging) sent to P2 (P2 se=amples for P1 and P4)	15	P11
	D1.1.5 – Chunky apple desserts (12 samples /ohmic plus 3 control) sent to P1, P3 and P4 for analysis, P5 for sensory and consumer characterization	18	P2
	D1.1.6 – Data on process variables for chunky fruit dessert processing sent to P8	18	P2
	D1.2.1 – Pilot for US processing at the 10-30 kg scale	9	P10
	D1.2.2 – Report on laboratory scale impact of PEF and US for juice extraction	15	P1 and P7
	D1.2.3 – Report on the structure measurement of PEF and US-treated apple mash	18	P1, P3 and P7
	D1.2.4 – P3 and P7 send stabilised samples of apples, juice and mash to P1, P3 and P4 for analysis and of juice to subcontractor PEIFL for sensory analysis	15	P3 and P7
	D1.2.5 – Report on impact of pretreatments on juice yields – pilot scale	27	P1, P3 and P7
	D1.2.6 – Samples of apple, juice and mash at industrial scale sent to P1 and P3 for analysis	36	P9
	D1.2.7 – Report on industrial scale PEF treatment	36	P3, P7, P9
	M1.1.1 - Choice of experimental conditions for pilot processing of purees with different viscosity during year 2	12	P2, P11
	M1.2.1 – Choice of protocol for PEF and US pilot scale trials of year 2 – from report on laboratory scale experiments	18	P1, P3, P7
	M1.2.2 – Choice of protocol for PEF plant scale trials – from reports on pilot scale and insertion of PEF unit in plant	30	P1, P7, P9

2. WP 2 Characterization of the products			
	D2.1.1 Report on characteristics and composition of apples and purees– from production of 4 purees of contrasted texture	12	P1, P2, P4
	D2.1.2 Report on characteristics and composition of apples, chunks and purees – from production of chunky fruit desserts	24	P1, P2, P4
	D2.1.3 Report on characteristics and compositions of apples, juices and mash – pilot plant pressings with/without PEF and US pretreatment	30	P1, P2, P3
	D2.2.1 Report on Feasibility of determination of PPO activity in processed samples after freezing	12	P4
	D2.2.2 Report on determination of PPO activity and markers of heat-treatment in raw and processed samples	24	P4
	D2.2.3 Reconstituted apple purees for texture analysis by sensory and physical means	10	P4
	D2.2.4 Report on characteristics and rheology of purees	24	P4
	D2.2.5 Report on cell wall evolution in purees (serum and particles) and chunks	24	P1
	D2.2.6 Report on texture of chunks as affected by ohmic heating	24	P1
	D2.2.7 Report on the rheological properties of the carrying phases before/after ohmic heating	24	P4
	D2.3.1 Report on sensory analysis of juices from pilot scale experiments	30	P3 (subcontractor)
	D2.3.2 Report on sensory analysis of reconstituted apple purees	18	P5
	D2.3.3 Report on sensory analysis of chunky apple desserts	30	P5
	M 2.2.1 Choice of conditions for stabilisation of raw and processed material for PPO analysis	12	P4
	M2.2.2 Feasability of reconstitution of apple purees for a wide range of texture	10	P4
	M2.2.3 Feasability and choice of method for fractionation of chunky apple dessert into puree and chunks	18	P1
3. WP 3 Consumer's perception			
	D3.1 – Report on Preference mapping for chunky fruit desserts	30	P5
	D3.2 – Report on Product concept test	30	P6
	D3.3 – Report on information effect on product preference	18	P6
	M3.1.1 Choice of 4 products for product concept test	24	P4, P5, P6, P9

4. WP 4 Modeling the processing impact on the products			
	D4.1.1 Report on interactions between ascorbic acid and polyphenols during heat treatment – kinetics and impact of temperature	12	P2
	D4.1.2 Report on interactions between heat-treated cell walls and apple polyphenols – affinity and saturation	24	P1
	D4.1.3 Report on Kinetics of PPO inactivation in heated model systems and processed samples	30	P4
	D4.1.4 Report on impact of cell walls on interactions between polyphenols and ascorbic acid	30	P5
	D4.1.5 Report on energies of interaction between apple polyphenols and cell walls	33	P1
	D4.1.6 Model of evolution of polyphenols and their diffusibility during time/temperature treatments	36	P8, P1, P2, P4
	D4.2.1 Model of relations between puree characteristics and rheology	30	P4,P8, P11
	D4.2.2 Relations between puree characteristics, rheology and perception	30	P4, P5, P8, P11
	D4.3.1 Model for time/temperature in ohmic heating	30	P8, P2
	D4.3.2 Model uniting polyphenols evolution in reactional models and for polyphenol evolution as function of product/process interaction in a heat treatment	36	P8, P1, P2, P4
	D4.3.3 Model for impact of PEF on quantitative and qualitative (polyphenols, PPO, pectins) of extraction from apple mash	36	P7
	M4.3.1 Experimental planning for pilot plant experiments	18	P8, P1, P2, P3, P7
Coordination à adapter en fonction de la durée du projet (coordination of the project)			
	Rapport d'avancement n°1 (report n°1)	6	coordinateur
	Rapport d'avancement n°2 + relevé des dépenses	12	coordinateur
	Copie de l'accord de consortium i projet partenarial	12	coordinateur
	Rapport d'avancement n°3	18	coordinateur
	Rapport d'avancement n°4 + relevé des dépenses	24	coordinateur
	Rapport d'avancement n°5	30	coordinateur
	Rapport d'avancement n°6 + relevé des dépenses	36	coordinateur
	Rapport d'avancement n°7	42	coordinateur
	Rapport d'avancement n°8 + relevé des dépenses	48	coordinateur
	Rapport de synthèse + récapitulatif des dépenses	48	coordinateur

6 - PROPRIETE INTELLECTUELLE / *INTELLECTUAL PROPERTY RIGHTS (IPR)* (½ page maximum)

The management of confidentiality, intellectual property and technology transfer will be described in a Consortium Agreement to be signed by all the partners. This document will define the governance structure of the project. Regarding IPR and exploitation of results, the following principles will apply :
- each partner will remain owner of its pre-existing know-how as well as of results obtained during the project with its own financial and human means ;
- results obtained jointly by several partners will be their joint ownership. Where possible the preferred form of protection will be in the form of registering for patent rights but other forms of IPR will be employed when deemed appropriate. A co-ownership agreement will be signed between the involved partners
- commercial exploitation of results will be carried out preferably by the industrial partners of the project, or by licensing out to third parties
- Confidentiality is defined in relation to pre-existing knowledge and for a period of 5 years. The partners undertake to publish the results, and acknowledge the project in these publications. All publication or communication projects will be communicated to the piloting committee prior to submission; when industrial properties rights or patenting may be in play, publications will be delayed on advice of the piloting committee until protection is established.

7 - AUTRES PROGRAMMES dont EUROPEENS / LINKS TO *OTHER PROGRAMS INCLUDING EUROPEAN ONES*

None of the existing programs cover precisely the same subject (process/ product innovation for increased nutritional density and acceptability). Related projects in which the participating teams are involved are listed below.

PI « ISAFruit » : FP6, 2006-2010 : fruit consumption through a transdisciplinary approach delivering high quaity produce from environmentally friendly, sustainable production methods.
URC, UMR SQPOV, ESA GRAPPE, UMR GENIAL, Val-de-Vire. – Participation to Pillar 3 « Processed products » : evaluation of scab-resistant apple cultivars for juice production, modelisation of drying of apple slices, study of extraction of active components from pomaces of apples and red fruits and their impact in fruit juices, understanding quinone-cell wall reactivity for the constitution of pomace.

Funding: circa 400 K€ all together

STREP « FLAVO » : FP6, 2004-2007. Flavonoids in fruits and vegetables: their impact on food quality, nutrition and human health. URC. : study of quinone reactio pathways, reactivity of and with tannins.

Funding: 90 K€.

PI « LYCOCARD » : FP6 , 2006-2011. Rôle du lycopène pour la prévention des maladies cardiovasculaires. UMR SQPOV : synthesis of lycopene derivatives for use in analysis and nutritional studies.

STREP OPTIM'OILS : Développer de nouvelles huiles à valeur nutritionnelle optimisée UMR GENIAL, UMR SCALE.

Projet ANR « Reactial » : 2007-2010 Prédiction et contrôle de l'apparition ou de la disparition de marqueurs réactionnels au cours de la transformation et de la conservation des aliments : UMR SQPOV, CTCPA, UMR GENIAL, UMR SCALE : identification and quantitative evaluation of polyphenols, carotenoids and lipid oxidation markers in tomato sauce. Funding : circa 45 K€

Projet ANR «Qualitomfil » : 2006-2009 : Construction et valorisation de la qualité organoleptique et nutritionnelle de la tomate tout au long de la filière. UMR SQPOV : fresh tomato texture, analysis and genomic determinants.

ACTIA 2006-2009 Impact des modes de préparation et de cuisson ménagères sur les qualités nutritionnelles des légumes frais et transformés UMR GENIAL

UMT 2006-2009 « Micronutriments des Produits Végétaux Transformés » CTCPA, UMR SQPOV : 100 K€/year

UMT 2006-2009 « Cidricole » : URC, 100 K€/year

Projet Région Pays-de-Loire Nutripomme 2006-2009 : Préservation des propriétés nutritionnelles et sensorielles des pommes au cours de différents procédés de transformation. ESA GRAPPE, URC.

JUSTIFICATION DES MOYENS HUMAINS ET FINANCIERS DEMANDES/ *RATIONALE OF THE REQUESTED STAFF AND FINANCIAL SUPPORT*

As a preliminary remark : in all the project rather high travelling expenses are planned : we have planned stays of students and permanent staff at other teams for some experiments (e.g. P1 and P10 to P3 for ultrasound application in pilot plant pressing, Ph.D of P11 and P4 to P2 for production of purees and P9 for sensory analysis…).

Partner 1 SQPOV

Means requested for SQPOV are consumables for experiments, travelling expenses including coordination and assistance to meetings for the Ph.D. theses, and equipment:
- in addition to the US pilot, which will be provided by P10, pilot-plant scale grater and solid/liquid separation; these will be used to carry out mechanistic studies on US extraction
- analytical equipment for quantifying polyphenol / cell wall interactions (microcalorimetry, not available at any of the partners) and for fractionation of plant material (preparation of purified polyphenols and cell walls in g quantities). It is planned that two students will carry out their Masters practical within the project (years 2 and 3).

Partner 2 CTCPA

Means requested for CTCPA are consumables and running costs for preparation of fruit purees, including the cutter for pieces (to be rented), plus consumables for analysis of pilot samples and of model solutions / suspensions.

Partner 3 URC

Means requested correspond to a Ph.D. thesis (cofinancing) and consumables for carrying out the thesis work, plus setting-up and control (analyses) of pilot plant experiments. They include travelling expenses for meetings within the project and trips of PhD and scientific to partner 7 (cotutor) and partner 9, and 3600 € for subcontractor PEIFL (sensorial assessment).

Partner 4 UMR-SCALE

Costs for UMR-SCALE include compensation for one student for 9 months. Other means are consumables necessary for the Ph.D. student recruited by P11 Héro France and various small equipements (notably for PPO measurement, fractionantion and reconstitution of purees, mechanical treatment of samples for texture and rheological cells and probes). Travelling expenses (4000 euros) correspond to meetings within the project and notably multiple trips to P5 GRAPPE and P11 Héro France which will be requested for co-tutoring of the Ph.D. student.

Partner 5 GRAPPE

In addition to personnel, including both scientists involved in data collection and analysis, and personnel included in the trained panel, costs of P5 GRAPPE are primarily the compensation of the 480 « naïve consumers » by buying coupons. Other costs are travelling and stay expenses for organisation of the consumer tests and consumables for training the expert panel.

Partner 6 UMR MOISA

Means requested include temporary staff for 3 months to help prepare the questionnaire for focus groups, recruiting of consumers and entering and analysing the collected data. During the last year, for quantitative survey, temporary staff for 5 months for data collection and entering, and participation to enconometric and statistical analyses.
Travel costs are relatively high due to need for close cooperation with partner 5 (Angers). Other expenses include renting of rooms for experimentation, maintenance and providing of equipement. Other costs include acquisition of software for lexical analysis and consumables for the surveys. Last, in the experimentation it is planned to give to each consumer a small sum (10-20€) which he/she must use to buy the products, in order to establish his/hers willingness to pay.

Partner 8 UMR-GENIAL

Most expenses are related to transportation (participation to many meetings), computer related expenses and human time (6 months of 2 permanent staff and 6 months of a postdoc for a total of 12 months).

P9 Val-de-Vire

Expenses are related to the organisation of an isolated pressing at industrial scale (40 T apples), further processing and analysis or resulting products.

Partner 10 REUS

Means requested correspond to the acquisition of parts for the equipment to be built and travelling expenses to the meetings and to site of use of the equipment (Avignon and Rennes), including trials and verification of good working order.

Partner 11 Héro France

Expenses listed in the program correspond to meeting and the organisation and internal analysis of production of contrasted purees (3T each), plus attendance to meetings. In addition a CIFRE Ph.D. thesis will be employed in the project and supervised by R&D staff (costs not asked here).

Récapitulatif des moyens humains / Human ressources						
Partenaire	Statut partenaire (Privé / public)	Nb mois cadre statutaire	Nb mois personnel technique statutaire	Nb mois cadre non statutaire	Nb mois personnel technique non statutaire	Total M/m
P1	PUBLIC	53,0	9,0	0,0	22,0	84,0
P2	0,0	4,6	8,2	0,0	0,0	12,7
P3	PUBLIC	16,0	20,0	0,0	36,0	72,0
P4	PUBLIC	13,0	9,0	0,0	9,0	31,0
P5	ASSOCIATION (>20 Salariés)	5,8	11,0	3,8	12,0	32,6
P6	PUBLIC	8,0	0,0	3,0	5,0	16,0
P7	PUBLIC	18,0	0,0	9,0	0,0	27,0
P8	PUBLIC	6,0	0,0	6,0	0,0	12,0
P9	PME (>= 20 Salariés, voir annexe AAP)	0,6	2,1	0,0	0,0	2,7
P10	TPE (< 20 Salariés)	4,0	0,0	0,0	0,0	4,0
P11	ENTREPRISE (Grande)	0,0	6,0	0,0	0,0	6,0
Total	0,0	128,9	65,3	21,8	84,0	300,1

BUDGET PREVISIONNEL ESTIMATIF EN COUT COMPLET							
Partenaire	Dépenses de personnel titulaire (1)		Dépenses de personnel temporaire (1)		Fonctionnement (2) (3)	Equipement (2) (4)	Total
	Cadre	Non cadre	Cadre	Non cadre			
P1	269 374,00 €	28 318,75 €	0,00 €	34 000,00 €	53 372,04 €	70 431,17 €	455 495,96 €
P2	24 259,27 €	21 943,94 €	0,00 €	0,00 €	73 533,00 €	0,00 €	119 736,21 €
P3	90 428,83 €	59 615,00 €	0,00 €	85 203,00 €	32 965,66 €	0,00 €	268 212,50 €
P4	79 491,83 €	26 515,58 €	0,00 €	7 500,00 €	43 048,40 €	0,00 €	156 555,82 €
P5	23 520,14 €	28 312,43 €	14 464,95 €	4 632,00 €	13 700,00 €	0,00 €	84 629,52 €
P6	38 000,00 €	0,00 €	9 600,50 €	9 622,08 €	16 007,50 €	0,00 €	73 230,08 €
P7	76 186,00 €	0,00 €	27 636,75 €	0,00 €	30 958,00 €	0,00 €	134 780,75 €
P8	30 262,50 €	0,00 €	19 201,00 €	0,00 €	8 096,64 €	0,00 €	57 560,14 €
P9	4 200,00 €	7 965,00 €	0,00 €	0,00 €	5 791,00 €	15 900,00 €	33 856,00 €
P10	13 333,33 €	0,00 €	0,00 €	0,00 €	7 800,00 €	21 000,00 €	42 133,33 €
P11	0,00 €	18 700,00 €	0,00 €	0,00 €	25 976,00 €	6 000,00 €	50 676,00 €
Total	649 055,90 €	191 370,70 €	70 903,20 €	140 957,08 €	311 248,24 €	113 331,17 €	1 476 866,30 €

(1) Dépenses de personnel y compris les charges sociales et les taxes afférentes selon le barème en vigueur dans chaque organisme ou entreprise considéré(e)

(2) Coût HT, majoré de la TVA rémanente pour les organismes publics

(3) Le fonctionnement comprend : petits matériels, consommables, fonctionnement divers, frais de mission, prestations de service et les frais forfaitisés.

(4) Matériel dont la valeur unitaire est supérieure à 4000 € HT

FINANCEMENT DEMANDE à l'ANR (exprimé en euro)							
Partenaire	Dépenses de personnel titulaire [1]		Dépenses de personnel temporaire [1]		Fonctionnement [2] [3]	Equipement [2] [4]	Total
	Cadre	Non cadre	Cadre	Non cadre			
P1	0,00 €	0,00 €	0,00 €	7 000,00 €	53 175,37 €	70 431,17 €	130 606,54 €
P2	12 129,63 €	10 971,97 €	0,00 €	0,00 €	36 766,69 €	0,00 €	59 868,29 €
P3	0,00 €	0,00 €	0,00 €	42 601,50 €	32 972,35 €	0,00 €	75 573,85 €
P4	0,00 €	0,00 €	0,00 €	7 500,00 €	43 049,62 €	0,00 €	50 549,62 €
P5	11 760,07 €	14 156,21 €	7 232,48 €	2 316,00 €	31 445,54 €	0,00 €	66 910,29 €
P6	0,00 €	0,00 €	9 600,50 €	9 622,08 €	16 036,62 €	0,00 €	35 259,21 €
P7	0,00 €	0,00 €	27 636,75 €	0,00 €	30 957,63 €	0,00 €	58 594,38 €
P8	0,00 €	0,00 €	19 201,00 €	0,00 €	8 096,55 €	0,00 €	27 297,55 €
P9	2 100,00 €	3 982,50 €	0,00 €	0,00 €	7 790,79 €	7 950,00 €	21 823,29 €
P10	8 000,00 €	0,00 €	0,00 €	0,00 €	6 198,40 €	12 600,00 €	26 798,40 €
P11	0,00 €	5 610,00 €	0,00 €	0,00 €	7 792,80 €	1 800,00 €	15 202,80 €
Total	33 989,70 €	34 720,68 €	63 670,73 €	69 039,58 €	274 282,34 €	92 781,17 €	568 484,21 €

(1) Dépenses de personnel y compris les charges sociales et les taxes afférentes selon le barème en vigueur dans chaque organisme ou entreprise considéré(e)

(2) Coût HT, majoré de la TVA rémanente pour les organismes publics

(3) Le fonctionnement comprend : petits matériels, consommables, fonctionnement divers, frais de mission,prestations de service et les frais forfaitisés

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CV of the coordinator

Renard Catherine

Date of birth : Dec 29, 1962, in Nantes (44)
Maried, two children

Education

- 1979: Baccalauréat (sciences).
- 1985: Pharmacist, Université de Nantes

- 1986: **Master**, Physico-chemistry of bioproducts, Université de Nantes
  Title: Study of mid-infrared diffuse reflectance spectra by factorial analyses. Application to wheat milling products
  Supervisor: Dr. D. Bertrand (Laboratoire de Technologie des Aliments des Animaux, INRA, Nantes).

- Nov 1989: **Ph.D. thesis** Université de Nantes, UFR Sciences, Physico-chemistry of bioproducts.
  Title: Apple cell wall polysaccharide : study by chemical and enzymic extraction methods.
  Supervisor Dr. J.-F. Thibault (director of LBTG)

- July 1998: **HDR**, Université de Nantes, école doctorale Chimie Biologie.
  No title.
  Supervisor Dr. J.-F. Thibault (director of URPOI)

Employment

INRA since dec 1986.

- Dec 1986: recruited as Ph.D. candidate at the Laboratoire de Biochimie et Technologie des Glucides (LBTG ; Biochemistry and Technology of Carnbohydrates), INRA (Nantes)
- July 1990 – Nov 2001: Chargée de Recherches
  Until sept 1998 : LBTG (name changed to URPOI: Unité de Recherche sur les Polysaccharides, leur Organisation et Interactions in 1998).
  Sept. 1998- Nov. 2001: Cider Research Unit, INRA (Rennes).
- Jan 2001 - July 2006: Head of the Cider Research Unit, INRA (Rennes).
  Nov. 2001 : Directrice de Recherche de 2ème classe.
- Since Aug. 2006 : UMR A408 « Sécurité et qualité des Produits d'Origine Végétale », INRA (Avignon). Head ot the « quality of fruits » team.

Main sojourns abroad

- Jan 1987 - may 1989: **Ph.D.** at the "Food Chemistry Laboratory" of Agricultural University of Wageningen (NL), under supervison of Prof. Pilnik and Prof. Voragen.
- Oct - nov 1990: "Mass Spectrometry of Macromolecules" (Prof. Boon), FOM-AMOLF, Amsterdam (NL).
- Sept 1996 - Sep 1997: **sabbatical** at "Agricultural, Food and Environmental Chemistry" (Dr. Jarvis), glsgow University (UK)

Areas of expertise

Catherine Renard obtained her Ph.D. at the University of Nantes in 1989 on the characterization of apple cell walls. The research for this Ph.D. was carried out during a 2.5 years stay at the Laboratory of Food Chemistry of the Agricultural University of Wageningen (NL). She worked from 1990 to 1998 at INRA Nantes on characterization of cell wall polysaccharides, more specially pectins, and their use in food products or non-food valorization for texture or ion-binding. In 1996-1997 she spent one year sabbatical at the University of Glasgow (UK) on use of solid-state NMR for structure investigation on cell walls and pectin gels. Since 1998 at INRA-URC she developped studies on interactions between apple

polyphenols and apple cell walls, developping a model to calculate transfer of tannins from apple to juice. As head of INRA-URC she was involved with studies on structure and oxidation of apple polyphenols, fermentation technology (limiting nutriments in cider fermentation and impact of anaerobiosis on yeast growth and volatiles of cider), polyphenol / enzyme interactions. Since 2006 work on characterization and genomics of fresh fruit (tomato, apricot) qualities.

Publications

74 publications in peer-reviewed journals (food chemistry and plant biochemistry), out of which 19 in Carbohydrate Polymers, 8 in Carbohydrate Research, 7 in J. Sci Food Agric, 6 in LWT-Food Sci and Technol, 5 in Int. J. Biological Macromolecules, 2 in J. Agric Food Chem. and in Phytochem.
1 patent, 5 chapters of books and 5 publications for the industrial public.
Supervision of 8 Ph.D. students and 20 Master students.
Organiser of the “European Workshop on Apple Processing”, Rennes, march 2005

Main projects

Participant:
FLAIR "Study of the production and utilization of fibres with enhanced functional qualities and beneficial nutritional properties", 1990-1994
AIR "New processes for the biological transformation of agricultural residues for the formation of high added value flavors", 1992-1996.
STREP 513960 “FLAVO Flavonoids in fruits and vegetables: their impact on food quality, nutrition and human health. 2004-2007.
“Cidre et polyphénols” 2000-2003 : Native polyphenols from apples to cider. Quantification, identification of mechanisms for their changes.

WP coordinator
PI 016279 ISAfruit increasing fruit consumption through a transdisciplinary approach delivering high quaity produce from environmentally friendly, sustainable production methods.

Langages

English and Dutch; Notions of Spanish.