



**SIXTH FRAMEWORK PROGRAMME PRIORITY [5]**



**SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT**

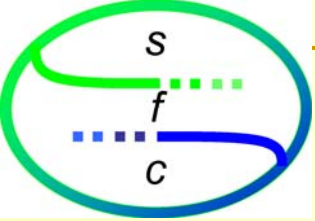


**REDUCING FOOD PROCESSING WASTE**

**Proposal/Contract no.: 006922**

Keith W. Waldron (Coordinator; Institute of Food Research, UK)

*Reducing food processing waste*



# Exploiting waste: 3 Socioeconomic Stakeholder Drivers:



## Legislative Driver

- Land-fill Directive  
*[derived from environmental  
and consumer pressures]*

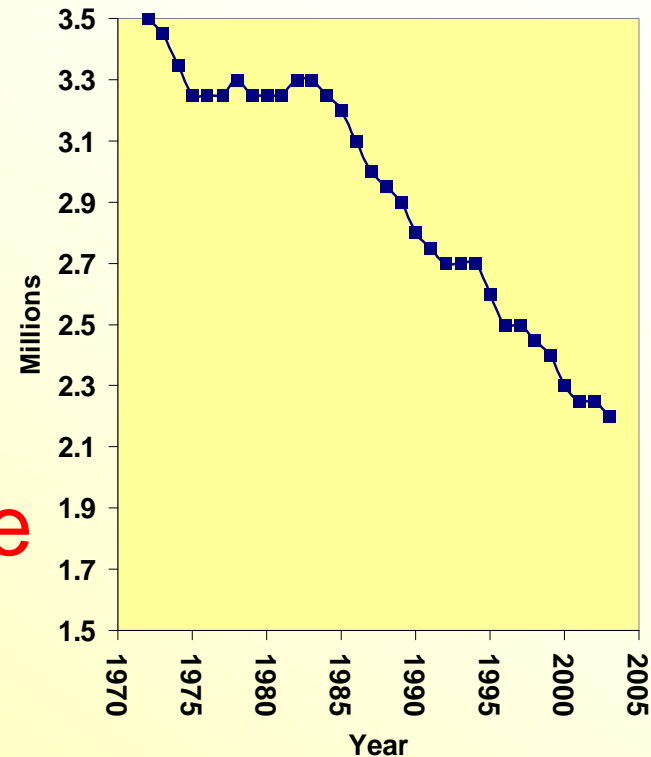
## Centralisation of processing

- Economies of scale
- Large localised production

## Energy costs and climate change

- Oil!
- Carbon emissions!  
*Impact on all aspects of food production*

Herd Size



DEFRA (2005)

# A) Introduction

## Key examples of plant residues



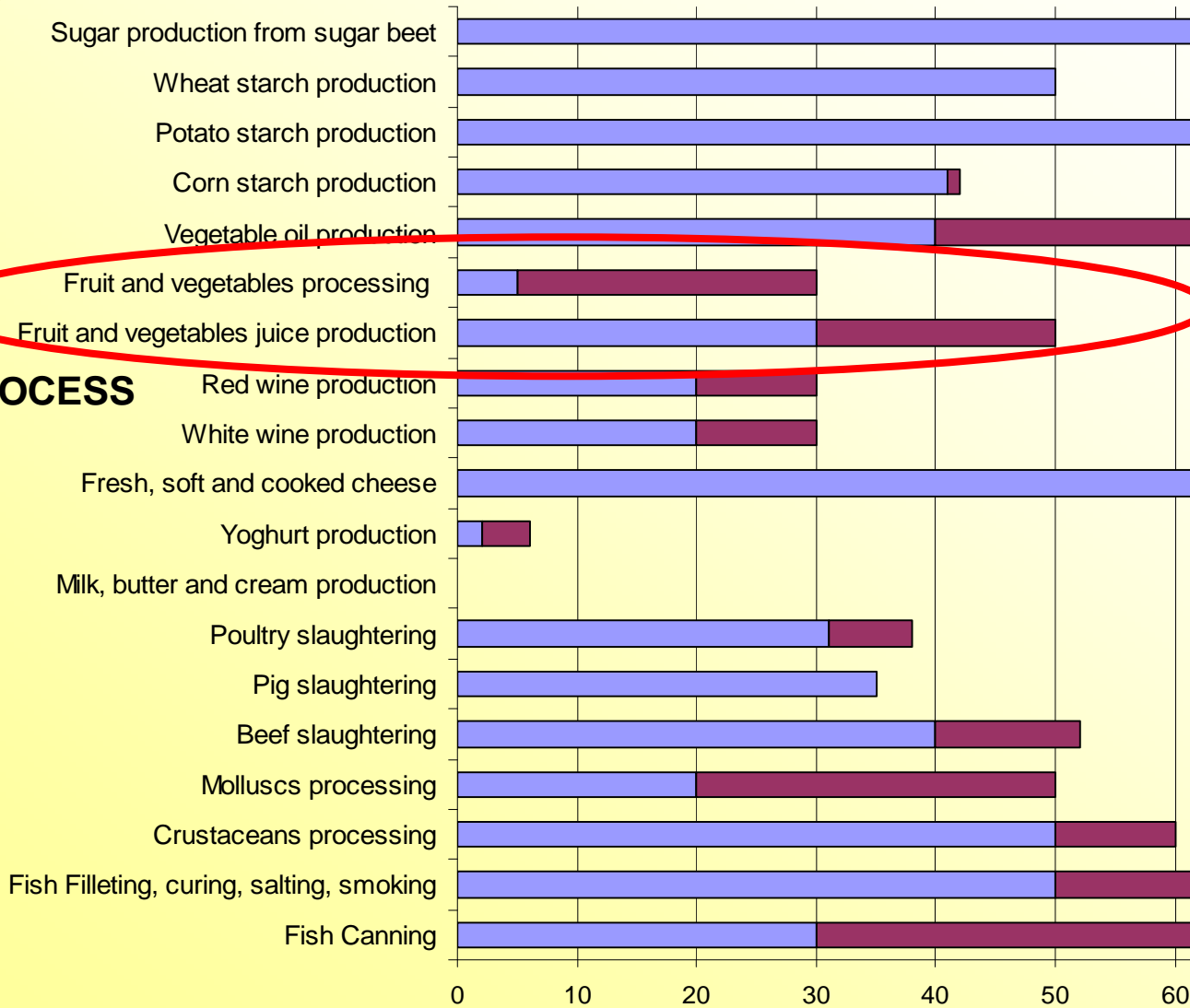
### SELECTED WASTE PRODUCED PER ANNUM IN EC COUNTRIES

Sugar beet pulp	4 840 000
Brewers spent grain	3 400 000
Fruit pulp (apple & peach)	310 000
Onion peeling waste	500 000

For most fruits and vegetables, one can estimate the likely waste as approximately 30% or more of the processed material.

*Reducing food processing waste*

# % non-utilised raw material



**PROCESS**

Reducing food processing waste %

**HANDBOOK FOR THE PREVENTION AND MINIMISATION OF WASTE AND VALORISATION OF BY-PRODUCTS IN EUROPEAN AGRO-FOOD INDUSTRIES**

AGRO-FOOD WASTE MINIMISATION AND REDUCTION NETWORK (AWARENET)

COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH PROGRAMME)

# How can the Food Industry maximise co-product Exploitation?



## Problems

**Microbiological instability**

**Heterogeneity of sources**  
– difficult to control quality



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# REPRO Partners



THE SWEDISH INSTITUTE FOR FOOD AND BIOTECHNOLOGY



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# AIM of REPRO

**To develop advanced methods:**

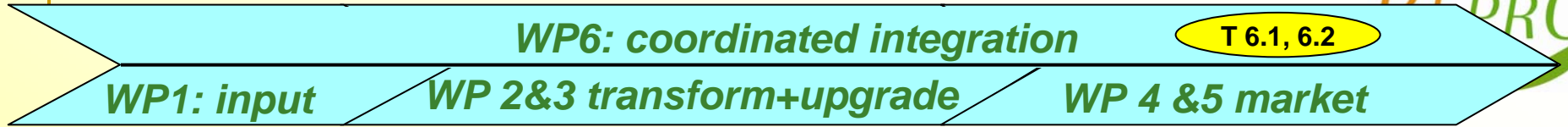
to *recycle and upgrade* food-processing organic waste co-products (by-products) into *high added value* food and feed products.



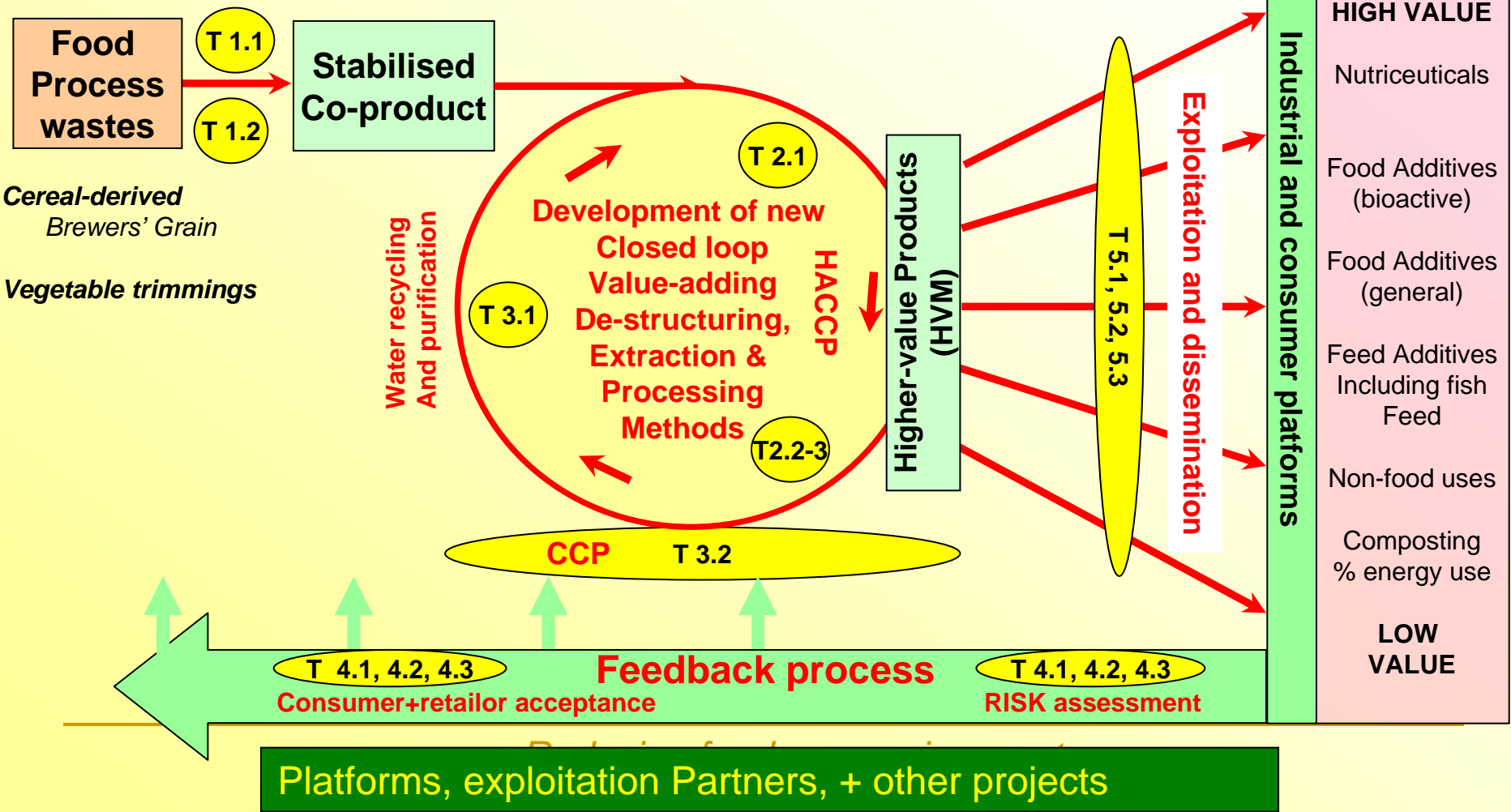
## 4 Interrelated activities and objectives

- 1) Development of approaches and procedures for microbiological **safety, stability** and co-product **traceability**;
- 2) Development of precision, enzyme-based bioprocesses to deconstruct and tailor co-product components;
- 3) Integration of the enzyme-based bioprocesses with modern physical processes, thereby developing **hybrid bio-processing systems**;
- 4) Minimisation of market risk for new processes by
  - (a) ensuring economic and environmental **acceptability**
  - (b) developing dissemination and exploitation routes

# REPRO



*Vision: Methods for Whole waste utilisation*





**WP6: Coordination**

**Task 6.1: Financial and internal business management**  
**Task 6.2: Scientific coordination and group learning**

**WP1: Co-product evaluation**  
•Traceability and stabilisation



**WP2: Bio component isolation and engineering**

- Develop biotools
- Develop enzymatic pre- and post-treatment methods



**WP3: Integration of biochemical and physical engineering**

- Integrate biochemical processing with solid/liquid processing
- Process design and optimisation



**WP4: Societal interface**

Risk assessment (legal)  
Socio-economic assessment (consumer)

Eco-efficiency



**WP5: Dissemination and exploitation**

Dissemination  
Impact and exploitation

Targeted exploitation



# WP1: Co-product evaluation and stabilisation

## Traceability:

- A database for management of traceability information has been produced
- All co-product streams relevant to the REPRO project (BSG and Vegetable Trimmings sources) have been assessed on a pan-European basis for traceability

## Stabilisation:

- Microbiological and chemical characterisation of sampled streams have been carried out in relation to:
  - (a) sourcing of streams
  - (b) storage of stream
  - (c) stabilisation of stream (development of HACCP)

# WP2: Biocomponent isolation and engineering



## Bioutil development:

- *Enzyme preparations*
- *Coprinus cinereus* cutinase produced in gram quantities and evaluated within REPRO (active on BSG and apple).

## Enzymatic disassembly of co-products:

### **Cereal disassembly**

- Unit process(es) for controlled release of specific and potentially functional oligosaccharides, peptides and insoluble residue (fed into WP3).

### **Vegetable trimmings:**

- Novel combination of enzymes identified for tissue liquefaction and extraction of high molar mass, low methoxy pectins.

***Unit process contributions have been fed into WP3 to enable process scheme development.***

*Reducing food processing waste*



## WP2 (Cont'd....)

### Recalcitrant Residues

- *Chemical approaches* employed to evaluate limiting cross-linking in the cell walls

### Combination process:

- Extrusion and enzymatic treatments developed.

# WP3: Integration of biochemical and physical processes



## Development and design of (3) full processing streams

### General simulation tool (+ microbiology):

Created, used to model processes and to generate input data for the evaluation of societal impacts and life cycle assessments in WP4.

#### 1) BSG-supplemented snacks:

- valorisation of BSG by producing an extruded chickpea snack



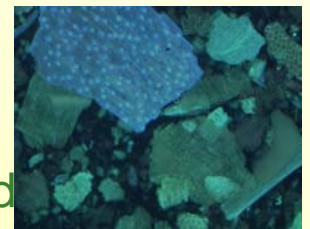
#### 2) VT valorisation:

- valorisation of red cabbage trimmings by producing
  - a colorant
  - Low-methoxy, high molecular weight pectin
  - functional polymer fragments and/or dietary fibre.



#### 3) BSG liquefaction and valorisation:

- enzymatic partial liquefaction of BSG and exploitation of solubilised components.



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## WP1: Co-product evaluation

- Traceability and stabilisation

## WP2: Bio component isolation and engineering

- Develop biotools
- Develop enzymatic pre- and post-treatment methods

## WP3: Integration of biochemical and physical engineering

- Integrate biochemical processing with solid/liquid processing
- Process design and optimisation



## WP4: Societal interface

Risk assessment (legal)  
Socio-economic assessment (consumer)

Eco-efficiency

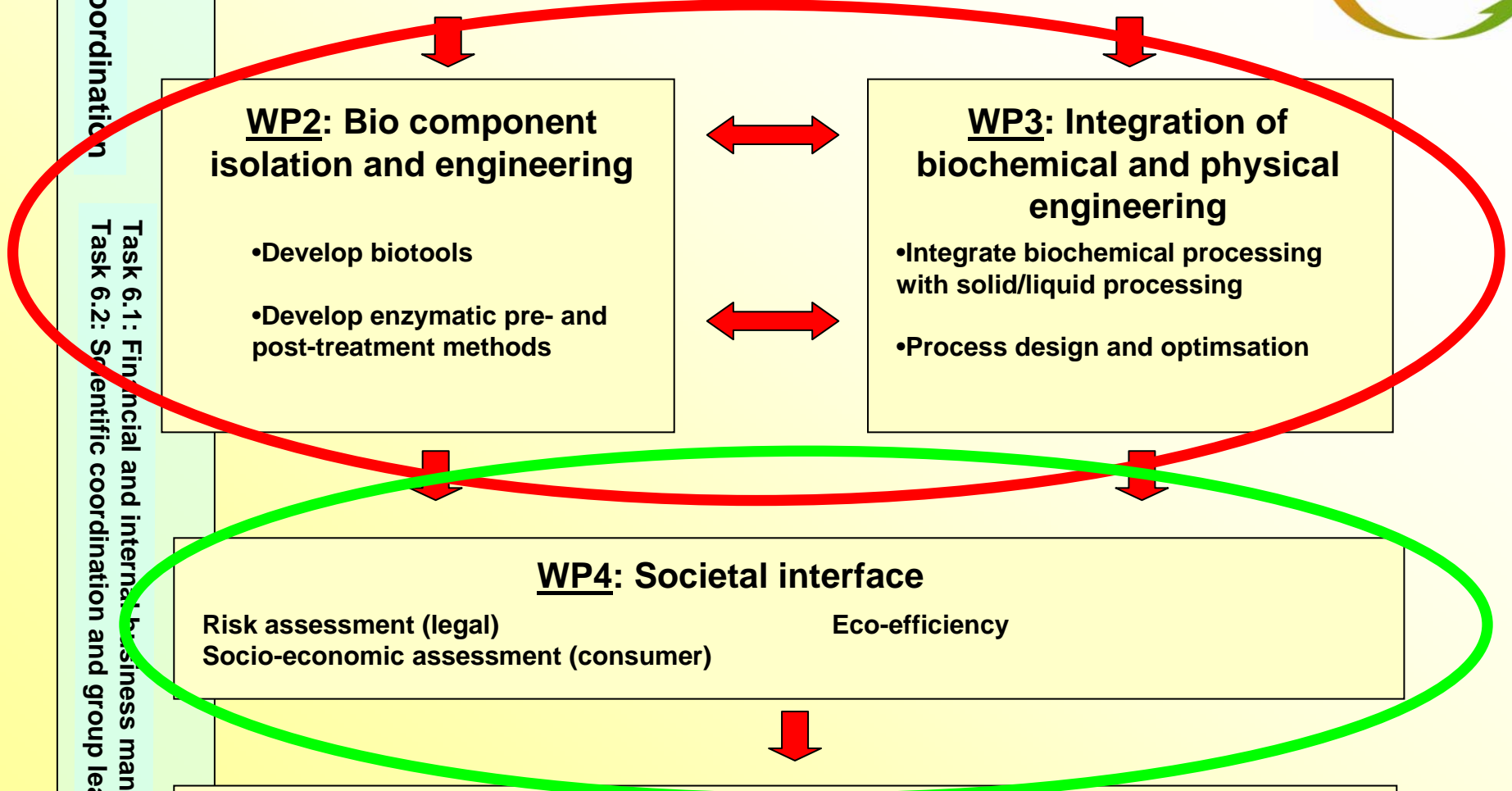
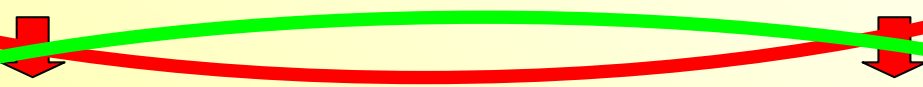
## WP5: Dissemination and exploitation

Dissemination  
Impact and exploitation

Targeted exploitation

WP6: Coordination

Task 6.1: Financial and internal business management  
Task 6.2: Scientific coordination and group learning



## WP4: Societal Interface

WP3 OUTPUTS ASSESSED;

### Legal Acceptance



Novel food issue is of importance in these waste streams. Stakeholders need to take decisions whether to submit a dossier for novel foods registration. Formulation of “Risk management options – how to meet regulatory requirements now and in the future”

### Cost-benefit analysis



BSG-supplemented snacks: costs are dominated by specific ingredients

VT valorisation: enzymes and energy.

Market value issues.

## WP4: Cont'd.....

### Consumer acceptance

Two-round **Delphy study**  
(to identify elements for  
evaluation)

**Focus group** discussions  
with consumers.

### Findings

*BSG extruded snacks    BSG liquefaction products    Vegetable trimmings*

- 1) **“high quality” ingredients perceived as “second grade” when produced from residue flows (or “waste”)**
- 2) **Consumers may not be prepared to pay a premium for them** (also indicated that they would not really want to know about their origin)
- 3) **Additional attributes**, such as potential health-benefits of coloured phytochemicals: not sought after specifically, but welcomed as a positive side effect and could contribute to acceptability.



# WP4: Cont'd.....



## Eco-efficiency

### Developing an LCA based method

A structured method for assessing the environmental assessment of novel products and processes has been developed.

LCA was assessed as defined by ISO 14040.

### Environmental effects included were:

- Global warming potential (GWP)
- Acidification (AP)
- Eutrophication (EP)
- Energy use (EU)



Image courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center."

## WP4: Cont'd.....

### Global LCA studies



#### BSG-supplemented snacks:

- Environmentally most beneficial to use the BSG in **snacks**, followed by **feed** and then **landfill**.

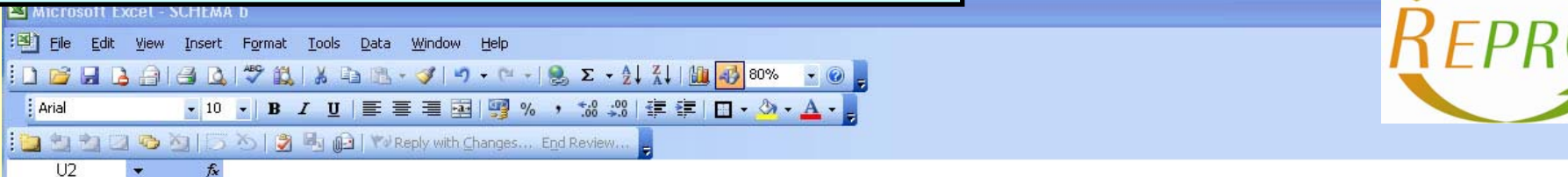
#### VT valorisation (Liquefaction of vegetable trimmings):

- Exploitation of VT by **liquefaction followed by fractionation** into exploitable components was considerably more environmentally friendly than using the VT for **cattle feed** or disposing of by **composting**.

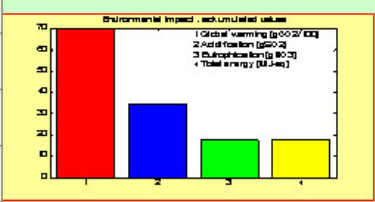
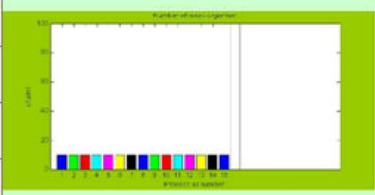
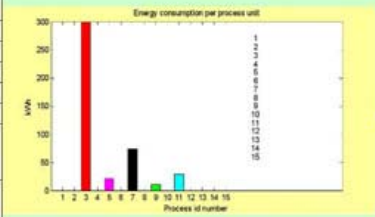
#### BSG liquefaction and valorisation:

- enzymatic costs were limiting from an environmental view point due to the high levels of fossil-derived energy used in their production.
- The intensive use of enzymes also creates higher eutrophication emissions.
- Beneficial in relation to acidification.

# REPRO RISK SCORECARD

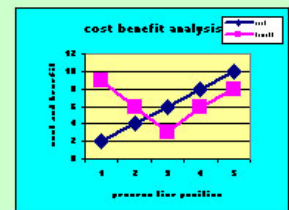


## Process Integration: (HYPOTHETICAL) **EXPLOITATION OF BSG IN EXTRUDED SNACKS**



PROCESSING SCHEME: ACCEPTABILITY CRITERIA AND RATINGS		
CRITERION No	DESCRIPTION	RATING
1	ENERGY UTILISATION	Green
2	MICROBIOLOGICAL SAFETY	Green
3	LIFE CYCLE ASSESSMENT	Green
4	LEGISLATIVE COMPLIANCE	Yellow
5	CONSUMER ACCEPTABILITY	Yellow
6	COST-BENEFIT ANALYSIS	Green
	OVERALL ASSESSMENT	Yellow

Input	BSG	Processed BSG (Energy, Protein, Fiber, etc.)
4330ms	Yellow	Green
Output	BSG chips in a snack	Green



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## **WP5: Targeted exploitation and dissemination**

### **1) Evaluation of novel fibre and rheologically-active products in emulsion-based food systems**

Recalcitrant residues from cereal products

- particle size and impact of complex mixtures,
- addressing problems of sedimentation of larger particles.

### **2) Fish feed production**

Fish feeding trials using feed supplemented with BSG-derived protein successfully carried out.

- Full data currently being evaluated.
- Interactions with large producers of farmed salmon.

# Dissemination

## TOTAL FOOD 2006

### Oral presentations:

- K.W. Waldron:** Whole by-product exploitation: an integration of research and technology in a market economy  
**P Forssell, H Kontkanen, J Buchert, H Schols, S Hinz, V Eijsink, J Treimo,** Potential of carbohydrate-degrading enzymes in valorisation of brewer's spent grain  
**J Robertson, C Faulds, A Smith, K Waldron;** Phenolic cross-linking and its application to manipulating bulk mechanical properties of cereal bran  
**J Buchert,** Use of enzymes in the food industry to improve product functionality  
**H Heeres,** EC legislation regarding production of safe food and feed  
**J Schroot, K Merck, S Hinz, H Schols, M Panouillé, E Bonnin;** Recovery of added value pectins and phytochemicals from Brassica trimmings by hybrid processes  
**U Sonesson LCA:** Joining up the food chain

### Posters:

- J Guijarro\*, L de las Fuentes;** REPRO interaction platforms: promoting the exploitation and upgrading of agro-food by-products  
**J Berlin, P Arinder, K Ostergren, P Ainsworth, J Schroot, U Sonesson;** Environmental analysis and predictive microbiology in combination as a tool for safe and sustainable process line design  
**Z Merali, JA. Robertson, AJ Jay, K l'Anson, AC Smith, TF Brocklehurst, CB. Faulds KW. Waldron;** Effect of storage on the exploitation potential of brewers' spent grain  
**P Ainsworth, V Stojceska, A Plunkett, S Ibanoglu** The effect of brewer's spent grain on the textural and functional properties of extruded ready-to-eat snacks  
**J Guijarro, A Urkiaga, I Garay, L de las Fuentes;** Development of potential applications of membranes and CO2 supercritical fluid in separation processes for valuable products recovery from agro food by-products  
**M Panouillé, S Durand, C Garnier, J-F Thibault, E Bonnin;** Enzymatic extraction of pectins from different plant by-products



EU Project No. FOOD-CT-2005-006922

Newsletter 2

EU Project No. FOOD-CT-2005-006922

Newsletter 3  
April 2007

Co-ordin

Dear Reader,  
REPRO is no progressing "biotools" ap products hav grated with s tion, direct p plored and ne

In order that a professio at the forthc 2006 Confer will be held information, p

There is an information; which are fre PRO website who will be p

My REPRO hope we can

Sincerely  
Keith Waldro

Co-ordinator's greeting

Dear Reader,  
REPRO is a European Commission-supported project which will help the Food Industry to become more sustainable. Many food processing firms produce large quantities of co-products which are of very low value. REPRO seeks to improve the exploitation of these co-products by:

- Developing approaches to maintain, where applicable, their food-grade status
- Developing novel processing methods for their disassembly and recovery.

The resultant novel ingredients will contribute to enhanced co-product exploitation.  
REPRO is now 2 years old, and is on target to successfully meet its key milestones and deliverables. We have demonstrated the potential to simulate complex processes for co-product exploitation in order to evaluate their total and unit-process impact on environmental, societal, legislative and economic criteria.

During the next year, we will be extending this approach to several additional novel exploitation routes, and will begin to disseminate these results for the purpose of industrial exploitation and further research opportunities (e.g. in FP7). To that end, we are now seeking association via our exploitation platforms with all parties with an interest in the exploitation of food processing co-products. Details of how to join (via: [www.repro-food.net](http://www.repro-food.net) or [repro@galiker.es](mailto:repro@galiker.es)) are presented within this newsletter.

Sincerely  
Keith Waldron (REPRO Coordinator)

In this issue:

- Co-ordinator's greeting
- 2006 EFFoST Annual Meeting Total Food 2006: Outcomes
- Repro Stakeholder Interaction Platforms: Industrial Platform
- Reduction of food processing waste: added value products from red cabbage trimmings
- Agenda
- Contact us

# REPRO website

A screenshot of the REPRO website interface. The top banner features the REPRO logo and the text "food processors to reduce disposal of co-product wastes". Below the banner is a navigation menu with links: Home, Your Account, Downloads, Submit News, Topics, and Top 10. The main content area is divided into several sections: "REPRO. Benefits" with a list of six bullet points, "Welcome to REPRO-FOOD" with a list of three bullet points, "Welcome to PHP-Nuke!" with a message and a link, and "Platforms" with a list of three items. There are also sections for "Modules", "Languages", and "Search".

**REPRO. Benefits**

Around 3,4 million tonnes of spent grain from the brewing industry trimmings from the vegetable processing industry (Eurostat data) and derived waste co-products are known to contain significant amount of unexploited waste in the current processes.

A sustainable future for food processors requires that these co-products are:

- Reduce the environmental impact of food waste (reducing odours)
- Enhance the sustainable management of organic materials to contribute to integrated resource and waste management (IRWM)
- Promote environmentally-friendly processing methods
- Increase industrial competitiveness
- Contribute to food quality and safety
- Provide with natural additives and components to food, feed and nutraceuticals
- Shift the technological exploitation of biomaterials (extensive use)

Economically viable up-grading requires whole-waste utilisation and therefore a very high degree of multidisciplinarity in the R&D process.

**Welcome to REPRO-FOOD**

Welcome to the REPRO public area. Herewith we provide interest parties with the following information

- the most project related news, updated every two months
- downloadable documents such as REPRO newsletters, food waste and by products related legislation, reports , etc
- a general glossary with the technical terms .
- REPRO related events, conferences, technical meetings, exhibitions and fairs
- useful links on food- technology, food- processes food-ingredients, etc

Furthermore, we are very willing to get your inputs, comments and suggestions to foster interaction with industrialist, technologist and society in general.

**Welcome to PHP-Nuke!**

Congratulations! You have now a web portal installed!. You can edit or change this message from the [Administration](#) page.

**For security reasons the best idea is to create the Super User right NOW by clicking [HERE](#)**

You can also create a user for you from the same page. Please read carefully the

**Platforms**

- Information sheet
- Platform affiliation questionnaire
- Members of Industrial Platform

**Newsletter**

- Nº 1
- Nº 2
- Nº 3

**NEWS**

Articles: 0  
Categories: 5  
Total Visits:

**News**

**The Best**

**Industrial platform**

*Reducing food processing waste*

# Total Food 2009

Total Food 2009 - Sustainability of the Agri-Food Chain

Sustainability of the Agri-Food Chain

22nd - 24th April 2009



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## Aim of Total Food 2009

Total Food 2009 is the third in a series of biennial international conferences which focus on the sustainable exploitation of agri-food co-products and related biomass, thereby helping to minimise waste.

This three day event will provide a forum to highlight recent developments and to facilitate knowledge transfer between representatives of the agri-food industries, scientific research community, legal experts on food-related legislation and waste management, and consumer organisations.

Themes to be explored will range from the adding of value to co-products through to the recovery of energy from waste streams.

The meeting will be run by the Institute of Food Research (IFR) under the auspices of the Royal Society of Chemistry Food Group, and will comprise plenary lectures, short talks, poster sessions, and focussed workshops. Proceedings will be published.

## Who should attend

Food and related industry and agri-food chain professionals interested in maximising utilisation of co-products, whole crop use and sustainability.



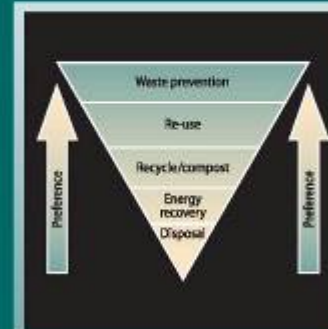
Total Food 2009 will be held in the Conference Facilities at the Norwich BioScience Institutes, Norwich Research Park, 4 miles west of Norwich, UK

# WASTE MANAGEMENT AND CO-PRODUCT RECOVERY IN FOOD PROCESSING (25 chapters)

- **Part 1:** Key drivers for waste minimization, management and co-product recovery in food processing
- **Part 2:** Optimising manufacturing to minimize waste in food processing
- **Part 3:** Key issues and technologies for food waste separation and co-product recovery
- **Part 4:** Waste management in particular food industry sectors and recovery of specific co-products
- **Part 5:** Minimising disposal: wastewater and solid waste management in the food industry

**Out Now!**

WOODHEAD PUBLISHING IN FOOD SCIENCE, TECHNOLOGY AND NUTRITION



## Waste management and co-product recovery in food processing

Edited by Keith Waldron



WP



Knowledge Transfer Networks: Accelerating business innovation; a Technology Strategy Board programme

Welcome Lesley Swift [Logout](#) [My Account](#) [Administration](#)

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<a href="#">Introduction</a>	<a href="#">Admin Only</a>	<a href="#">Activities</a>	<a href="#">Waste Database</a>	<a href="#">Published Information</a>	<a href="#">Links</a>	<a href="#">Collaboration Space</a>	<a href="#">Non Food Issues - Biofuels</a>	<a href="#">Green Energy Issues</a>	<a href="#">Non Government Organisations</a>	<a href="#">Government Organisations</a>	<a href="#">Regional Development Agencies</a>	<a href="#">Research</a>



- Government
- Research and Technology
- Information, Data and Statistics
- Funding
- Knowledge and People Transfer
- Education
- Eco Design

## Welcome to Food Chain Sustainability Special Interest Group

Welcome to the SIG (Special Interest Group) Website, this website has been developed by the Institute of Food Research in conjunction with the Knowledge Transfer Network to form the basis of a Centre of Excellence in relation to sustainable food issues.

This site has been developed as a result of the evolution of the [Institute of Food Research's](#) (IFR) Co-Product Exploitation Cluster which forms part of the [Food & Health Network](#) (FHN). The Cluster's aim was to develop innovative methods for extracting marketable components and ingredients from food chain co-products, as a result of its success, this website was created.

The website aims to provide a Centre of Excellence and strives to be the foremost site relating to sustainable food issues. It is therefore important that we keep abreast of developments within the sustainable food chain, and specifically with scientific developments and technologies relating to sustainable food. Therefore, we endeavour to up-date this site as new developments in both science and technology evolve.

Here you can find:

- Information on issues relating to sustainability throughout the food chain
- Links to other sources of information
- On-line discussion groups
- Partner searches
- Academic and industrial resources

The site is continually being developed. If you want to be kept informed of the latest news please contact: [Lesley.Swift@bbsrc.ac.uk](mailto:Lesley.Swift@bbsrc.ac.uk)

## What is 'Food Chain Sustainability'

# Future Activities



- **Translation of expertise and experience** into
  - “biorefinery” research and development
  - Lignocellulose exploitation (biofuels)
  
- **Formulation of new project** to provide:
  - Modelling approach to describe and evaluation risks of hypothetical co-product exploitation routes.

