
C&E Spring Meeting 2009
- Whole Grain Global Summit
Whole Grain Products : the Holy Grail for Health Conscious Consumers ?
NEWCASTLE upon Tyne,
United Kingdom, March 25-27, 2009
• Consumer drivers
• Challenges to the industry
• Science and Technology
• Nutrition
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C&E Spring Meeting 2009—Whole Grain Global Summit

Whole Grain Products: The Holy Grail for Health Conscious Consumers?

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Dear Friends and Colleagues,

I am delighted to welcome you to this special supplement to Cereal Foods World, which contains the full programme and abstracts submitted for presentation at the 2009 Cereals&Europe Spring Meeting—Whole Grain Global Summit, held in Newcastle University, Newcastle upon Tyne, U.K., March 24–27, 2009.

This will be the second C&E Spring Meeting, following the highly successful inaugural meeting held in Montpellier in 2007. It is also the third in a series of Whole Grain Global Summits (after meetings at VTT, Finland, in 2001, and at the University of Minnesota, U.S.A., in 2005), and I am delighted to have been asked to host this special meeting at Newcastle University.

Cereals&Europe is the European arm of AACC International and represents the largest grouping of cereal-based R&D professionals in Europe. The meeting was developed to bring together these experts with nutritionists and consumer scientists to debate the worldwide drive to promote the use of whole grains in human nutrition. The use of whole grains and their role in nutrition and health, and in food manufacturing cannot be more topical. Regulatory bodies, including the European Food Safety Authority (EFSA) in Europe and the FDA in the United States, are currently debating ways to promote their use, legislate on associated health claims, and establish workable definitions of "whole grain" and "wholegrain foods." These organisations are charged with ensuring that the best interests of consumers are safeguarded, taking into account the industry's requirements in regard to the claimed health benefits of whole grains. At the same time, industry must meet the challenges of developing tasty, safe, and affordable wholegrain foods that consumers will purchase.

The aim of the C&E Spring Meeting 2009—Whole Grain Global Summit is to contribute to the discussion and inform these policymakers with a state-of-the-art and interactive programme, presented by leading experts from industry and the academic world.

Two additional activities are included in the programme. First, there will be an open discussion forum to further discuss definitions of "Whole Grain" in collaboration with the AACC International Whole Grain Task Force, ICC, and the EU Integrated Project Healthgrain networks. Second, a half-day symposium organised by the GRAINITY project, a consortium of researchers from the Nordic countries, will focus on rye.

The Plenary Session reviews progress made since the 2005 Whole Grain Summit in Minneapolis, MN, U.S.A., followed by four controversy-seeking presentations on the lead topics of the conference: nutrition, technology, consumer perception, and EU vs. U.S. regulatory and labeling issues. These key themes continue in four sessions with invited speakers and submitted papers showcasing the latest whole grain research. An "interactive" half day ensures active participation with alternating poster sessions and topical moderator-led workshops, picking up the same themes as the parallel sessions.

The structure of the meeting will ensure close integration of nutritionists, food technologists, food processors, and regulatory affairs experts, offering a truly global, multidisciplinary perspective.

The meeting is sponsored once again by AACC International and we are grateful for their generous help. It has also attracted tremendous support from our industry sponsors—thank you all. Take time also to examine the International Scientific Committee without whom this meeting would not have been possible.

Chris Seal, Programme and Scientific Committee chair
Peter Weegels, Cereals&Europe chair

C&E Spring Meeting 2009 - Whole Grain Global Summit

Tuesday 24th March

08:00		
12:30	Registration open	Foyer Herschel
	Poster Set up	WG WS
14:00		Whole Grain Taskforce Workshop — Lth 1
16:00		COFFEE BREAK
18:00		

Wednesday 25th March

		GRAINITY SYMPOSIUM	
08:00	Registration open		
9:00	GR01	Lth 1	Exhibit set-up
9:20	GR02		
9:40	GR03		
10:00	GR04		
10:20	COFFEE BREAK		Lindisfarne Room
10:40	GR05		
11:00	GR06		
11:20	GR07		
11:40	GR08		
12:00	LUNCH		
	PLENARY		
14:00	Welcome	Curtis auditorium	
14:20	PL1		
14:40	PL2		
15:20	PL3		
16:00	COFFEE BREAK		
16:30	PL4		
17:10	PL5		
18:00	Welcome Reception	King's Hall	

Thursday 26th March

	PARALLEL I nutrition, physiology, mechanisms	PARALLEL II technology, sensory, raw materials
8:00	Registration open	
9:00	S101	S201
9:30	S102	S202
10:00	COFFEE BREAK	
10:30	S103	S203
10:50	S104	S204
11:10	S105	S205
11:30	S106	S206
11:50	S107	S207
12:10	S108 (Curtis auditorium)	S208 (Lth 1)
12:30	LUNCH	
	Foyer/Lth1/Curtis Auditorium	
	INTERACTIVE SESSION	
14:00	Posters I	WS I
14:45	WS II	Posters II
15:30	COFFEE BREAK	
16:00	Posters III	WS III
16:45	WS IV	Posters IV
19:30	Reception	Magpie Suite NUFC
20:00	Dinner	

Friday 27th March

	PARALLEL III phytochemicals, processing, analysis	PARALLEL IV regulations, labelling, new evidence
8:00	Registration open	
9:00	S301	S401
9:30	S302	S402
10:00	COFFEE BREAK	
10:30	S303	S403
10:50	S304	S404
11:10	S305	S405
11:30	S306	S406
11:50	S307	S407
12:10	S308 (Curtis auditorium)	S408 (Lth 1)
12:30	LUNCH	
		Exhibit take down
14:00	PLENARY and SUMMARY (Curtis auditorium)	
15:30	Adjourn	
	COFFEE BREAK	
18:00		

AACC International Whole Grain Task Force Workshop

Tuesday, March 24, 2009 • 14.00 – 18.00

Chairs: Julie M. Jones, College of St. Catherine, U.S.A.; Kaisa Poutanen, VTT, Finland; Jan Willem Van der Kamp, TNO, The Netherlands

The AACC International Whole Grain Task Force (WGTF) began its work three years ago, in December 2005. In that time it has addressed a number of issues. The WGTF works through conference calls with academics, industry, non-profit agencies, and government participants. There are core participants who regularly attend the calls. In addition, there are individuals with special interests or expertise who may participate from time to time. There is an attempt to have various industries and areas of the world represented. Furthermore, the work of the WGTF is strengthened by smaller expert task forces convened to deal with issues specific to processing of traditional whole grain foods barley, bulgur, and liming of corn (nixtimalization) or participation by regulatory people from groups such as Health Canada.

The workshop will focus on:

- Discussion to date of the AACC Intl. Whole Grain Task Force – Prof. Julie Jones
- Debate from the November 2008 Open Discussion Forum meeting in Paris, organized by HEALTHGRAIN – Jan Willem Van der Kamp
- Compatibility of whole grain definition(s) and EFSA approval of health claim (Prof. D. P. Richardson
- Reactions to the recent definition(s) survey

The role of the WGTF is to try to use science to answer questions that are important for moving the whole grain agenda forward with the following objectives:

1. To encourage the use of whole grain products in many venues.
2. To provide a science background as the basis for promulgation of rule-making by entities that label and encourage whole grain product use.
3. To set definable scientific standards which help industry with product formulation and labeling guidelines. This will help minimize proliferation of multiple standards that will paralyze consumers and manufacturers.
4. To provide the consumer greater clarity in the marketplace in order to select whole grain containing foods.
5. To support the use of foods made with a blend of whole and enriched grains, but that contribute significant whole grain content to the diet - not just foods that are entirely or almost entirely manufactured with whole grains. This will enable manufacturers to add whole grain to their lines and will allow consumers to adapt to products containing whole grains.
6. To use science to help make certain that industry develops whole grain products which deliver the nutritional advantage and are not simply functionally expedient.

While much of the activity has had a North American focus up until now, the WGTF has felt the need to be complemented by a European discussion forum. This is timely when EFSA will be taking decisions about generic nutrition and health claims very soon. The forum could review and comment the decisions and questions by the AACC Intl. Forum, and raise questions which are important for European developments. With this workshop, WGTF is following up on discussions held in Europe as well as in the U.S.A. on a regular basis. The workshop will be prepared with the input of members of AACC International, Cereals&Europe, HEALTHGRAIN project, and ICC.

Chairs: Kaisa Poutanen, VTT, Finland; Herman Adlercreutz, University of Helsinky, Finland; Per Åman, Swedish University of Agricultural Sciences, Denmark; and Knud Erik Bach Knudsen, Aarhus University, Denmark

GRAINITY—Wholegrain, rye and oats, the Nordic opportunity—is a project financed by Nordic Innovation Centre as part of the functional foods focus area in 2006–2008. The objective is to provide a scientific discussion forum and platform to assist in the development of healthy rye and oat-based foods, and to discuss related nutrition communication as well as their role in dietary strategies. In this Satellite Symposium, experiences and research results of the consortium are featured both from scientific and application points of view.

GR01 09.00–09.20
Wholegrain, rye and oats—Nordic academia-industry interaction in a 15-year perspective
Ingmar Borjesson
Lantmannen Food R&D, Järna, Sweden

Nordic cooperation between strategic research groups and engaged industrial partners has a long and important history. Most of the partners in the NICe-funded project GRAINITY have been working actively together in the same constellation since 1993. With a mixture of scientists, convinced to study the health impact of whole grain cereals, and health minded industries it has been easy to find ways to continue the cooperation even when no common project was keeping the group together. The original reason for this cooperation was the decrease in consumption of products with special health impact e.g. rye bread. The group has developed and shared knowledge important for a continuous development of new products and relevant information to consumers. Companies competing at the market have found common grounds to support studies of joint raw material basis, and to promote the research of products of Nordic interest. It can be of special notice for other teams to hear about the engaged and positive interest this group has paid to continue its meetings even when no research project was setting the agenda. This concern has resulted in yearly meetings with the whole group during a period of more than 15 years. The close interaction between members from academia and industry has enabled development of special dissemination tools for uptake of the results in the companies.

Fifteen years may not seem to be such a long period, but taking into consideration that during this period there have been at least four different joint projects, with all the partners involved, it is a proof for special driving forces.

GR02 09.20–09.40
The dietary fibre complex of rye grain
Per Åman
Department of Food Science, SLU, Uppsala, Sweden

Rye grain is considered as a healthy ingredient which adds variety to the bread and breakfast cereal markets. Among cereals rye is similar to wheat, despite significant differences in chemical composition and technological properties. Rye is mainly consumed as whole grain and epidemiological studies suggest that consumption of whole grain cereals are associated with reduced incidences of chronic diseases, e.g., diabetes, cardiovascular disease, and certain cancers. Intake of rye may also increase satiety and reduce the risk of weight gain. The mechanisms behind the health effects of rye are to a large extent unknown but have been related to a high content of dietary fibre and associated bioactive components in the so called dietary fibre complex.

Among cereals rye has the highest content of dietary fibre, about 16%. This content is mainly due to a high amount of cell walls within the starchy endosperm, containing mainly arabinoxylan and to a lesser extent β-glucan. More insoluble dietary fibre components dominate in the outer part of the grains. Rye is rich in many bioactive compounds with potential health effects. These include certain minerals and vitamins as well as phenolic compounds, lignans, phytosterols, phytostanols and alkylresorcinols.

In this presentation the structure and content of dietary fibre components will be presented. Molecular weight distributions and changes in molecular weight during processing of extractable arabinoxylan and β-glucan in rye will be discussed. Fructan and fructooligosaccharides may be included in the dietary fibre value and rye is rich source of these components, which may increase the dietary fibre content in rye with as much as 4% units.

The localization and content of certain bioactive components such as vitamins, plant sterols and stanols, lignans and alkylresorcinols will also be discussed.

GR03 09.40–10.00
The "rye factor"—rye bread has beneficial effects on glucose homeostasis
Kaisa Poutanen[1,2], Hannu Mykkänen[2]
[1]VTT Technical Research centre of Finland, Espoo, Finland, [2]University of Kuopio, Kuopio, Finland

Rye bread is a nutritionally important component of the Eastern and Northern European diets. Traditional and also new types of soft and crisp breads are in many cases based on whole meal rye flour, making rye bread a remarkable source of dietary fibre especially in Finland and Denmark.

It has been repeatedly shown in postprandial studies in healthy humans and also in persons with metabolic syndrome that Finnish rye breads produce a lower insulin response, but not that of glucose, as compared to white wheat bread. However, three hours after the wheat bread meal the plasma glucose level declines below the fasting level, whereas glucose level is maintained above the fasting level after the rye bread meal. Inhibition of the late postprandial decrease in blood glucose by rye bread appears to reduce the release of counter-regulatory stress hormones and rebound of free fatty acid concentrations in serum. The difference in the postprandial insulin response after rye products as compared to other cereals cannot be explained solely by the amount of fibre, since also "white" rye bread made of endosperm flour similarly lowers postprandial insulin response.

Two recent interventions have shown that a daily intake of whole meal rye bread over 8–12 week period results in improved glucose homeostasis measured by either intravenous or oral glucose tolerance test. A diet rich in rye bread was also shown to down-regulate gene expression in the adipose tissue, including the genes linked to insulin signalling and apoptosis, as compared to a diet containing wheat and oat breads with similar content of fiber but higher postprandial insulin responses.

Rye bread structure has been suggested to play an important role in the lower postprandial insulin response to rye bread, also called "the rye factor". As rye bread typically is made by the sourdough process, the changes induced by the interplay of endogenous enzymes and fermentation, such as acid production, proteolysis and arabinoxylan solubilization, may contribute. The role of phenolic compounds and other phytochemicals, high especially in wholemeal rye bread, also remains to be elucidated.

GR04 10.00–10.20

Wholegrain fibre as a substrate for large intestinal butyrate formation

Knud Erik Bach Knudsen, Peter Kappel Theil, Helle Nygaard Lærke
Aarhus University, Faculty of Agricultural Sciences, Tjele, Denmark

Butyrate is a C4-carbon acid produced by microbial fermentation of carbohydrates and protein in the large intestine of non-ruminant species. Butyrate is absorbed by passive diffusion to the portal vein and serves as energy substrate for the epithelial cells lining the large intestine. Additionally, butyrate has important implications during cell proliferation and differentiations and scarce supply of colonocytes with butyrate has been linked to colon cancer. The production of butyrate is primarily regulated by amount and composition of the dietary residues that escape digestion in the small intestine. The range of carbohydrates that arrive in the large intestine from the diet is enormous, but a major contributor is fibre polysaccharides; β-glucan, arabinoxylans (AX), and cellulose when feeding cereal based diets. These polymers arrive in various states and solubility, chain length and association to other molecules. A substantial proportion of β-glucan and AX is solubilised following their release from the cell wall structure, and it has been shown that the rate and overall degree of degradation of these polymers is influenced by the chemical structure, the solubility, and the degree of lignification. Thus, β-glucan and soluble AX are rapidly degraded in the cecum and proximal colon while the more insoluble polysaccharides, e.g. cellulose and insoluble AX, is degraded more slowly at more distal locations of the colon. Amount and rate of degradation of the individual polysaccharides will have a profound influence not only on the total production of short-chain fatty acids (SCFA: acetate, propionate, and butyrate) but also on the molar proportion of the produced acids. Thus, fermentation of AX rather than β-glucan stimulated the formation of butyrate (absolute and relative) in a manner that is linked to the flux of AX to the large intestine.

GR05 10.40–11.00

Alkyresorcinols in whole-grain rye and wheat as biomarkers of cereal fibre intake

Herman Adlercreutz
Folkhälsan Research Center, Helsinki, Finland

Alkylresorcinols (ARs) are phenolic lipids abundant in the outer layers of rye and wheat grain, but absent in most other foods. They have long side-chains (15 to 25 carbons) making them highly fat-soluble. Sixty per cent of the ARs are absorbed from the small intestine without conjugation via the lymphatic system. They are circulating in blood bound to the lipoproteins and also to red cell membranes. ARs are metabolized to two small molecules called DHBA (3,5-dihyroxybenzoic acid) and DHPPA (3-3,5-dihydroyphenyl)-1-propanoic acid) and are excreted in urine. It has been suggested the ARs could serve as biomarkers of whole-grain intake. The ARs have, however, short half-lives (5h) but in preliminary experiments in human subjects the metabolites seem to have longer half-lives making them more suitable for use as biomarkers of cereal fiber intake. Methods for both urine and plasma metabolites have recently been published.

The methods were evaluated in a material consisting of young (20) and old (20) omnivorous and vegetarian women and in healthy women operated for small breast cancers (16)(BC) 3 to 6 months earlier. Food records were obtained during 5 days in spring and autumn. Cereal fibre intake correlated significantly with plasma AR C17:0, AR C19:0, AR C21:0, AR 23:0, AR 25:0 and total AR (r=values from 0.283 to 0.428; p-values from 0.05 to 0.001)). Cereal fibre was also significantly correlated with urinary DHBA (r=0.372; p=0.005) and DHPPA (r=0.408; p=0.002).

High estrogen levels or prolonged exposure to estrogens (hormone therapy) are risk factors for BC. In earlier studies we have shown that intake of fibre, particularly cereal fibre, reduces the estrogen levels in the body by reducing their absorption and increasing their faecal output. About 50% of estrogens in the body are excreted in bile and undergo an enterohepatic circulation and can be influenced by fibre in the diet. We found now that the healthy women with operated breast cancer had significantly lower plasma DHBA (p=0.007; p=0.031) and DHPPA (p=0.021; p=0.012) and low cereal fibre intake (p=0.007; p=0.003) compared to the omnivores and vegetarians, respectively. Thus the BC subjects consumed a diet low in cereal fibre.

GR06 11.00–11.20

Impact of energy and rye bran intake on incidence and mortality of prostate cancer: Can tumour progression be inhibited by changes in life style?

Hallmans Göran
Department of Nutritional Research, Umeå University, Umeå, Sweden

Ecological and migration studies as well as animal studies have shown that energy excess in relation to energy expenditure are related to prostate carcinogenesis and that the relationship is particularly evident for advanced disease. There is some epidemiological evidence that the impact of energy intake is strongest in males with aggressive disease. Support of the "energy hypothesis" is given by a randomized trial where a low fat, vegan diet combined with exercise six times per week have given promising results on the progression of prostate cancer in patients on "watchful waiting" with one year of follow up.

Studies on plasma concentrations of insulin and prostate cancer have given strong support for the concept that the impact of insulin and factors associated with insulin on prostate cancer growth is age dependent with a protective association of c-peptide in younger cases. It is evident that metabolic and hormonal factors act differently on tumour progression than on tumour initiation in different ages. In older men with prostate cancer the results are more pointing in the direction of an adverse effect of insulin on tumour progression and death. These results are supported by observations of an increased cancer mortality seen in diabetes patients treated with insulin or sulfonylureas, by the impact of the insulin-like growth factor-1 (IGF-I) and by the association with type 2 diabetes of various stages.

In a number of epidemiological and experimental projects the impact of diet and some metabolic risk factors have been studied on the progression of prostate cancer. Inhibited tumour growth and increases in tumour apoptotic index have been found associated with intake of rye bran, soy protein and purified lignans in some animal models. In a randomised controlled short-term intervention human study an increased apoptotic index of prostate cancer have been observed in subjects given rye bran for 3 weeks. That study is now followed up in a randomized, cross over experiment. The epidemiological studies performed on lignans and prostate cancer have given conflicting results.

Conclusion: It is from a quality of life perspective important to provide a realistic alternative for the large group of individual with prostate cancer on "watchful waiting". If changes in life style including diet may provide some help it may even reduce the burden for the health care system of complications of prostate cancer in a significant way.

GR07 11.20–11.40

Rye and oats—Innovative processing and ingredients

Pekka Lehtinen, Anu Kaukovirta-Norja, Kaisa Poutanen
VTT Technical Research Centre of Finland, Tietotie 2, Finland

Both rye and oats are highly suitable raw materials for various high dietary fibre food products and ingredients. The driving force for the development of new rye and oat products is the capability of rye products to deliver dietary fibre and the strong evidence relating the intake of oat beta-glucan with the improved control of cholesterol. In addition there is increasing evidence on the effect of rye intake on the insulin responses and thus protection for type 2 diabetes.

During the period from 1960 to 2000 consumption of rye products in Finland decreased from 30 kg/capita to 15 kg. However, after 2000 there has been a remarkable increase in the usage of rye products. This increase is based on the dissemination of health benefits of rye and also on the development of wider selection of rye products. The fractionation technology to tailor sensory properties, content of nutritionally important constituents and baking properties has been in central role in developing new rye ingredients.

The majority of oat that is used for food production has traditionally been wholegrain oat flakes or oat bran. In the recent years, new types of oat products have emerged in the markets. The development of these products has involved new type of oat ingredients and novel processing technology. These have relied on the sophisticated fractionation technologies and on the use of enzymes as processing tools. Also by adapting strict quality control it has been possible to produce oat products free of other cereal making it possible for celiac patients to include wholegrain oats in the diet.

Especially oats have also been adapted in products beyond traditional bread making. Beverage oat products have been developed to be used as high fiber replacement for milk. Both rye and oat are also used in snack products, breakfast cereals and ready made frozen dough. New products are constantly developed and increasing knowledge on the mechanisms of health effects of these cereals provides more concrete aims for this. development work.

GR08 11.40–12.00

Exploitation and communication of research—How is it reflected in products and consumption figures?

Sampsa Haarasilta

Fazer Bakeries Ltd, Helsinki, Finland

In Nordic countries the milling and baking industry like the trade is concentrated. There are rather big baking and milling companies and these are also investing somewhat into research. A comprehensive Nordic industrial consortium started in 1994 the Nordic "Rye and Health" research project. The stimulus for the project was professor Adlercreutz and his plant oestrogen hypothesis. One of the best insights of the project planning team was to have a communication plan for the project. The research topic attracted media and even the signing event of the research contract got a lot of space in the news.. During the first years rye and its health effects was described in numerous articles in Finnish newspapers, magazines, radio and TV. The same happened, but in a much smaller extent, also in Sweden. Today in the mind of the Finnish people there is nothing as healthy as rye bread. The project resulted in interesting and useful scientific findings, as well. Based on the common knowledge capital generated by the project companies have taken different approaches in their commercial applications. One of these is the Fazer Rye Fibre and bakery products based on this special fibre preparation. The success of Fazer Rye Toast is a living example of the importance and opportunities that research offers even in a very old and traditional business. Milling statistics show that after a long decline there has been already for many years a steady growth of rye milling tonnages in Finland. The author's personal opinion is that a major part of this is to be ascribed for the successful research projects, including the communication, which began about 15 years ago.

Plenary Session • Wednesday, March 25, 2009 14.00–18.00

PL1 14.10–14.40
Whole grains: Working together to solve tomorrow's public health issues
Len Marquart
University of Minnesota, St. Paul, MN, U.S.A.

Whole grains, fiber, and bioactive components are an integral platform for the advancement of the grains and health industry. Considerable research is underway to explore the biological, consumer and technological aspects of grain foods throughout the continents. As we move into the next decade, there is a need to focus and prioritize grain-related research efforts among scientists to more effectively target and leverage our research dollars. Additional issues include the development of collaborative research projects that address identified gaps in the supply chain which in turn enhance the development and delivery of whole grain / fiber foods to the consumer. Lastly, academic programs are encouraged to develop visionary leaders who can communicate across sectors, disciplines, and cultures and possess the necessary skills to comfortably navigate the supply chain. Academic programs that emphasize multi-disciplinary, interdependent teams in the development of grain-based food products that are sustainable, cost-effective and reduce risk for chronic disease are prerequisite to empower future scientists and health professionals to solve today and tomorrow's public health issues.

PL2 14.40–15.20
Whole grains and health, evidence from observational and intervention studies
Chris Seal
Newcastle University, Newcastle upon Tyne, U.K.

'Consume more whole grains' is a mantra transmitted by nutritionists, dietitians and food manufacturers. Government agencies across the developed countries also advocate increased intake of wholegrain foods, with several countries developing guidelines which include setting recommended daily amounts. The bulk of the evidence to support these messages has come from observational studies, in some cases including cohort studies with follow-up. The data from these studies are a powerful indicator of the relationship between whole grain-intake and improved health, however, such relationships do not demonstrate causality. Nevertheless the strength of this evidence cannot be disputed, particularly for the benefit of whole grains in reducing cardiovascular disease risk. Repeated meta-analyses show that CVD risk is reduced by approximately 30% when comparing the lowest whole grain consumers with the highest whole grain consumers. To help explain the benefits of whole grain, and in particular to confirm and develop health claims for wholegrain foods, intervention studies are needed to link observational data with mechanistic explanations. Until recently the number of intervention studies with wholegrain foods has been small; most have included subjects at high risk (e.g. obese subjects, hypercholesterolaemic subjects), and most are of short duration. However, data from larger and longer-lasting interventions are gradually appearing. In some cases the results of these studies support the observational data, but in others they do not. This paper will compare and contrast the observational data with that from intervention studies to try and reconcile these differences and make recommendations for future research.

PL3 15.20–16.00
Can the demands for wholegrain foods be met by technological processes?
Michael Gusko
Kampfmeyer Mühlen, Germany

Today, foods made with whole grains are recognized as important sources of nutrients including fibre, trace minerals, certain vitamins and health-promoting phytochemicals. The health benefits of whole grains are well documented. According to recent polls consumers are increasingly seeing the link between diet and health. More and more, consumers are looking at preventive measures to stay healthy and improve their sense of wellbeing. That includes exercise, and it includes diet as a major component. However, convincing consumers to eat more whole grains, especially in the amount recommended, has been unsuccessful. In the battle for the winning "share of the stomach" other healthy foods (like probiotic yoghurts or pure fruit smoothies) are suspected to win the competition against whole grain foods. Adults and children give a variety of reasons for not choosing whole grain foods, including these: the unpleasant taste and unappetising look of most whole grain foods, a lack of understanding of the health benefits of whole grain foods, an inability to identify whole grain foods.

Food technology has to face the challenge formulating whole grain foods consumers are looking for. To help solve such complex problems, not only new technologies, but also conventional milling technologies in combination with innovative raw material sourcing strategies have to be mobilized. Food technologists also have to get acquainted with the bioavailability concept. It identifies the degree to which a nutrient substance becomes available to the target tissue after administration. Innovative whole grain ingredients can increase the absorption of healthful nutrients. Innovative higher technical capabilities have to be built up by applying new findings from the related disciplines to allow the food technology to play its vital role. Food technology has to be emphasized to increase the availability of appealing whole grain foods and innovative foods with "wholegrain power".

PL4 16.30–17.10
Consumer and market drivers for wholegrain foods
Filip Arnaut
Puratos, Belgium

Current consumer consumption patterns show that wholegrain foods are becoming more popular, also in areas where there is no tradition in consuming wholegrain foods.

This is in line with current and projected consumer trends in which a growing awareness of the importance of a healthy gut is very present. Also, an increasing interest in ancient grains and a search for new textures sustains this evolution.

Whether this will be a long term change in consumption patterns will depend on different factors. Some countries set up ambitious long term stimulation programs for whole grain foods but at least as important will be the availability of fair priced, great tasting products. This means a thorough understanding of consumer needs and preferences and translating this in new products and new product categories.

Apart from this, the wholegrain food will also have to bring real advantages for the consumers. Whole grain or specific fractions of whole grains will have to bring benefits that are scientifically proven: to comply with legislation, and to bring a clear message towards the health conscious consumer. It is also clear that more than by the scientific

evidence the consumer is convinced by tangible effects. Especially in these challenging times the products will have to convince more by their performance.

The growing category of wholegrain foods offers an opportunity to the baking industry and this will be illustrated by several cases.

PL5a 17.10–18.00

Regulatory aspects for whole grain and wholegrain foods: A U.S. view

Julie Jones
College of St. Catherine, St. Paul, MN, U.S.A.

Whole grains have been shown to have many health advantages. Therefore, many companies are adding whole grains to their products and consumers are looking for these foods in their diets. Making regulations that encourages industry to formulate products with whole grains and accurately conveys to the consumer the amount of whole grain in the product creates many challenges. Further the label should give enough information to enable the buyer to know whether of the product is delivering a dietarily significant amount of whole grain. Labeling regulations create a level playing field so that consumers know what is in the product and all manufacturers have the same opportunity to express the benefits for their products. In order to establish regulations regarding whole grains, there first needs to be an agreement as to which grains are included and which are not. Next, there needs to be agreement on what definition is being used for whole grains. In the USA the AACC Intl. definition of whole grains is widely used in industry. However, as grains are processed in various ways there needs to be attention paid to the effects of thee various processes on the proportions of the kernel required to meet the AACC Intl. definition of whole grains. Further, there needs to be a vehicle that tells the consumer the amount of whole grain in a product. Label declaration of the amount of whole grain required and the amount in the product can help consumers with food choice. The FDA approved health claim for whole grains is one way to label whole grain products. Since it is based on product weight, not dry weight, it gives lower moisture products an advantage. It also has a fiber amount required, and this gives an advantage to those whole grains with higher fiber contents such as wheat and barley. Traditional processing of foods such as the making of bulgur, the pearling of barley and the nixtimalization of corn offer special challenges to the definition and for regulation. All these will be discussed.

PL5b 17.10–18.00

Regulatory aspects for wholegrain and wholegrain foods—An EU perspective

Nino Binns
NBConsulting, Dublin, Ireland

Wholegrain and wholegrain foods enjoy recommendation as part of many national and international dietary guidelines. However, if the food industry makes claims for the health benefits of wholegrain foods, then a raft of regulatory requirements must be met in the European Union. Under the relatively recent EU regulation on nutrition and health claims made on foods (Regulation (EC) No 1924/2006 OJ L12, 18.01.2007 p. 3) any nutrition claims about the energy, nutrients, fibre or other beneficial substances the food contains need to comply with the Annex of that Regulation. As far as health claims are concerned, until January 2010 food businesses may use any health claims that can be validated by scientific evidence (see also Richardson DP Abstract S401) providing that they meet any specific requirements of the Regulation that are applicable prior to that date and providing they are not (a) prohibited claims or (b) claims referring to a reduction in the risk of disease or a disease risk factor or (c) referring to children's development and health or (d) claims that have been rejected by the EU regulatory procedure. Claims under (b) or (c) require submission of a dossier. Once the list of so-called Article 13 health claims is published (for the main part expected in Jan 2010), then only those claims included in the list or those claims approved following submission of a dossier to EFSA may be used. Wholegrain foods making nutrition and health claims will also ultimately have to respect the nutrient profiles that will be established in spring 2009. A definition of what counts as a wholegrain food has been proposed for the UK by the Institute of Grocery Distribution (IGD) but this has no regulatory standing. The conditions of use that will be documented as part of the EU-approved list of health claims may in essence establish a definition.

Parallel Session 1 • Thursday, March 26, 2009 09.00–12.30

Nutrition and health effects of whole grains

Chairs: Susan Jebb, MRC-Human Nutrition Research, Cambridge, U.K; Margaret Bath, Kellogg Co., U.S.A.; Filip Arnaut, Puratos, Belgium

S101 09.00–09.30

Potential health benefits of avenanthramides of oats

Mohsen Meydani
Jean Mayer USDA HNRCA at Tufts University, Boston, MA, U.S.A.

A high intake of fruits, vegetables, and whole grain foods is associated with a lower risk for coronary heart disease (CHD) and cancer. In addition to having dietary fiber, whole grain foods are a rich source of many good nutrients. Although the presence of fiber in whole grain foods is believed to be the major factor inducing their health benefit effects, the contribution of other components of whole grains and the mechanism by which whole grain foods provide health benefits have not been clearly identified. Oats (*Avena sativa L.*) are unique among the cereal grains. The consumption of oatmeal and oat bran has been shown in most studies to reduce total plasma cholesterol and LDL-cholesterol, which are the main risk factors for CHD. This is mainly attributed to the soluble fiber, β-glucan content. In addition to its cholesterol lowering effect, oat consumption has recently been shown to improve endothelial function and to reduce blood pressure.Oats in addition to containing a number of phytochemicals with antioxidant properties it contains the major phenolic compounds, called avenanthramides (Avns), which are not present in other cereal grains. The bioavailability of Avns has been demonstrated in hamsters, and in humans. The potential protective effect of Avns on vascular function and on the prevention of atherosclerosis has been attributed to their protection of LDL oxidation. Using the cell culture system, we have examined the potential health benefit of Avns-enriched extract of oats in modulation of cell and molecular processes that are known to play an important role in the inflammation of arteries and development of atherosclerosis. Avns inhibit vascular expression of adhesion molecules, including ICAM-1, VCAM-1, and E-selectin and inhibit adhesion of monocytes to EC and reduces the production of several inflammatory cytokines including IL-6, IL-8 and MCP-1through modulation of NF-κB. Avns also increases nitric oxide (NO) production and suppress VSMC proliferation through modulation of several cell cycle regulatory proteins including p53, p21*cip1*, p27*kip1*, cyclin-D1 and pRb. In addition, Avns of oats are capable to inhibit proliferation of colonic cancer cells without having any effect on normal colonic epithelial cells. These findings suggest that Avns of oats provide a broad range of health benefits, which complement the already known health benefits derived from oats. Supported by the USDA agreement No. 58-1950-7-707.

S102 09.30–10.00

Whole grains and gut health

Joanne Slavin

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Whole grains contain all parts of the grain, the endosperm, germ, and the bran (1). Whole grains are rich in fermentable carbohydrates that reach gut – dietary fibre, resistant starch, and oligosaccharides. Most research that supports the importance of grains and gut health was conducted with isolated fibre fractions, rather than whole grains. Whole grains are an important source of dietary fibre and grain fibres such as wheat, oats, barley, and rye are known to increase stool weight, speed intestinal transit, get fermented to short chain fatty acids, and modify the gut microflora (2). Wheat bran is particularly effective in increasing stool weight with wheat bran increasing stool weight by a 5 to 1 ratio. In contrast, many novel fibres that are easily incorporated into beverages and foods increase stool weight only on a 1:1 ratio. *In vitro* fermentation studies with whole grains have been published. Carbohydrates of oat bran (rich in beta-glucan) were consumed by the bacteria faster than those of rye and wheat brans (rich in arabinoxylan) (3). Grain fibres were fermented more slowly than inulin and there was less gas production. Wheat is particularly high in fructo-oligosaccharides while wheat germ in high in raffinose oligosaccharides. Some *in vivo* studies show the probiotic potential of whole grains. Whole grain breakfast cereal was more effective than wheat bran breakfast cereal as a probiotic, increasing faecal bifidobacteria and lactobacilli in human subjects (4). Wheat bran consumption increased stool frequency. Thus, the gut enhancing effects of cereal fibres are well known. Limited data exist that whole grains alter gut health.

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S103 10.30–10.50

Validation of alkylresorcinols as biomarkers of whole grain wheat and rye intake

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Department of Food Science, Swedish University of Agricultural Sciences, Uppsala, Sweden

Epidemiological studies have shown a clear reduction in risk of several chronic diseases such as coronary heart disease and diabetes type 2. A major obstacle in nutritional epidemiology which might weaken the diet-disease association is the relatively low accuracy in measuring the intake of foods and nutrients. Assessing whole grain intake is further complicated by the fact that consumers may have difficulties in recognizing products containing whole grains and different definitions have been used. Using a biomarker of whole grain intake would overcome some of the problems associated with dietary assessment and might be used to validate other methods.

A group of phenolic lipids, alkylresorcinols (AR), seems to fit many of the general criteria for a biomarker of whole grain wheat and rye intake. In two human intervention studies we showed that plasma AR was correlated to intake assessed by weighed food records and that it increased linearly within a broad intake range. Also total AR metabolites in 24-h urinary collections increased in the same way, showing a plausible dose-response relation, which is a fundamental requirement for a biomarker. Another important criterion of a biomarker is the reliability, i.e. the precision, which determines the minimum number of samples that can be used for estimating the average plasma concentration of a subject during a certain time period. In a third intervention study with very high plasma AR intakes, we estimated the intraclass correlation coefficient (ICC) to about 0.8 for plasma AR, showing that a single sample will estimate the underlying average plasma AR concentration in a subject with a precision of 20% (80% CI). In a fourth study, using samples from the prospective Danish Nutrition, Cancer and Health study, we demonstrated that rye bread intake assessed by a semi-quantitative food frequency questionnaire (FFQ) was the major significant determinant of plasma AR concentration in Danish women and that non-dietary factors such as BMI and serum cholesterol did not affect plasma AR concentration. The results from the conducted studies suggest that AR can be used as biomarkers for wheat and rye intake in populations where the whole grain intake is high and stable.

S104 10.50–11.10

Sourdough fermentation of wholemeal wheat bread reduces glycemic responses in subjects with insulin resistance

Jenni Lappi[1], Emilia Selinheimo[2], Pekka Lehtinen[2], Ursula Schwab[3,4], Hannu Mykkänen[3], Marjukka Kolehmainen[1], Kaisa Poutanen[1,2]

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Intake of wholegrain foods, as well as foods with slow glycemic response, is associated with reduced risk of chronic diseases. Since glycemic responses to breads made of wholemeal flour are high, retarding the glycemic response of a wholemeal bread would further increase its health benefits. The aim was to study postprandial glucose and insulin responses of wholemeal wheat breads in relation to baking technology. Breads were baked using 100% flour from peeled (2%) wheat kernels by straight dough or sourdough fermentation method, and with or without addition of xylanase during mixing of dough. Standard white wheat bread was used as reference. Eleven subjects with insulin resistance and features of the metabolic syndrome were served the breads in random order. Each test bread portion contained 50g of available carbohydrate. Blood samples for measuring glucose and insulin concentrations were drawn at eight time points over four hours. Nutrient composition and the content of soluble protein of the test breads were determined. *In vitro* hydrolysis of protein and molecular weight of the protein hydrolysates were also performed. The wheat bread produced using sourdough fermentation had the lowest postprandial glucose and insulin responses. Plasma glucose concentration was lower at time points 45, 60, 90 and 120 min ($p<0.05$) and higher at 240 min ($p<0.01$) as compared with the reference. Furthermore, serum insulin concentration was lower at the time point 90 min ($p<0.05$). The postprandial responses were not improved by addition of xylanase. Sourdough fermentation and xylanase treatment increased the amount of water-extractable arabinoxylan, while the latter also led to increased depolymerisation of water-extractable arabinoxylan. In the sourdough fermented bread, the content of soluble protein was the highest and the MW of the hydrolysed proteins the smallest. In conclusion, sourdough fermentation resulted in a bread with the most favourable postprandial glucose and insulin responses among the three tested wheat breads made of peeled kernels. Possible mechanisms by which fermentation produces this effect are low pH, increased arabinoxylan solubilisation, and proteolysis. The reduced postprandial response achieved by sourdough fermentation may further encourage the use of wholemeal wheat bread by persons with insulin resistance.

S105 11.10–11.30

Colonic fermentation of indigestible carbohydrates of a previous evening meal increases tissue glucose uptake

Marion Priebe[1], Hongwei Wang[1], Alexandra Small[2], Tom Preston[2], Roel Vonk[1]

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Evening meals rich in indigestible carbohydrates have been shown to lower postprandial glucose concentrations after ingestion of a high glycemic index breakfast. This phenomenon is linked to colonic fermentation of indigestible carbohydrates but the underlying mechanism is not fully elucidated. We examined in which way glucose kinetics after the breakfast are changed due to colonic fermentation. In a cross-over manner 10 healthy male subjects (21 ± 2 years, BMI: 21,4 ± 1 kg/m^2) ingested as an evening meal either white wheat bread or cooked barley kernels, rich in indigestible carbohydrates. In the morning the dual isotope technique was applied to determine exogenous glucose appearance in the systemic circulation, endogenous glucose production and tissue glucose uptake after intake of 50 g ^{13}C-enriched glucose. Plasma insulin and non-esterified fatty acid concentrations were measured as well as hydrogen excretion in breath. Postprandial glucose response was 29% lower after the barley evening meal, whereas the concentrations of insulin and non-esterified fatty acids were the same. Exogenous glucose appearance in the systemic circulation and endogenous glucose production did not differ, but tissue glucose uptake was increased after the barley evening meal. Hydrogen excretion was higher after the barley meal indicating increased colonic fermentation. Factors related to colonic fermentation of indigestible carbohydrate have the ability to increase tissue insulin sensitivity in healthy subjects.

S106 11.30–11.50

Impact of whole grain inclusion on biomarkers of cardiovascular disease risk in a large-scale randomised, controlled dietary intervention (the WHOLEheart study)

Iain Brownlee[1], Carmel Moore[2], Mark Chatfield[2], David Richardson[3], Peter Ashby[4], Sharron Kuznesof[1], Susan Jebb[2], Chris Seal[1]

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Background: Observational evidence suggests that increased whole grain (WG) consumption is linked to reduced risk of cardiovascular disease (CVD). Methods: 316 overweight participants (age 18–65y, BMI>25 kg/m^2 but otherwise healthy) who habitually consumed <30 g WG/day were recruited in 2 UK study centres (Newcastle and Cambridge). Participants were randomised to 3 groups: Control (no dietary change), Int.1 (consumed 60 g WG/day for 16 weeks) and Int.2 (consumed 60 g WG/day for the first 8 weeks, followed by 120 g WG/day for a further 8 weeks). Duplicate fasting blood samples were taken at weeks 0 (baseline), 8 and 16 of intervention. Wholegrain intake was assessed by food frequency questionnaire. Plasma was analysed for lipid profile (total, LDL and HDL cholesterol and triglycerides), insulin and glucose and further biochemical markers of inflammation and endothelial function. Differences between study groups were compared using a random intercepts model with time and WG intake as factors. Results: Mean WG consumption was <20g/day at baseline. The mean (SD) WG intake for each group during the intervention was: Control 19 (20) g/day across the intervention, Int.1 74 (29) g/day for weeks 8 and 16, Int.2 76 (31) g/day at week 8 and 115 (40) g/day at week 16. The primary outcome in this study was plasma LDL cholesterol. WG inclusion in the diet had no impact on this, or any of the other biomarkers of CVD risk tested (P>0.05). Mean (SD) LDL cholesterol (at week 0, 8 and 16 respectively) were 3.2 (0.9), 3.2 (0.7), 3.3 (0.8) in the Control group; 3.1 (0.9), 3.2 (0.7), 3.3 (0.8) in Int.1 and 3.2 (0.9), 3.3. (0.8), 3.4 (0.9) in Int.2. During the intervention, WG participants mean LDL was -1.01% different from control mean (95%CIs -3.65%, 1.71%). Conclusions: Reported WG intake compliance was good throughout the study. Inclusion of WG foods, over 16 weeks, in the diets of an overweight but otherwise healthy UK population had no effect on a range of CVD risk biomarkers. Dietary intervention data do not match epidemiological observations on WG and CVD risk. *This study was funded by the UK Food Standards Agency (N02036).*

S107 11.50–12.10

Effect of consumption of either whole grain wheat or rye as the sole whole grain source on plasma lipid profiles in healthy volunteers (the GrainMark study)

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Background: Increased intake of whole grains (WG) may result in lower blood cholesterol concentrations, but the effects vary for different grains due to the amount and type (soluble *vs* insoluble) of fibre present.

Methods: 67 participants (32 male, 35 female, mean age 54.6 (SD 5.86) years, mean BMI 25.6 (SD 3.17) kg/m^2) took part in the study. Participants were asked to exclude all WG foods from their diet for 4 weeks (washout period), after which they were randomised to 2 intervention groups, Wheat (WG-W) and Rye (WG-R). Participants were given a range of either wheat- or rye-based WG foods and asked to consume 48 g WG/day for 4 weeks, followed by 96 g WG/day for a further 4 weeks, but to avoid all other forms of WG in their diet. Fasting blood samples were taken after the washout period (baseline), 4 and 8 weeks of intervention. Plasma were analysed for lipid profile (Total, LDL and HDL cholesterol and triglycerides (TAG).) Results: Lipid concentrations (mean (SD)) for the two groups at the 3 time points are shown below:

	Baseline (after washout)		Week 4 (48 g WG/day)		Week 8 (96 WG/day)	
mM	**WG-W**	**WG-R**	**WG-W**	**WG-R**	**WG-W**	**WG-R**
Total-C	5.86 (1.07)	6.10 (0.85)	5.82 (1.06)	5.96 (0.94)	5.74 (0.95)	5.88 (0.85)[a]
LDL-C	3.58 (0.96)	3.89 (0.82)	3.52 (0.95)	3.72 (0.85)	3.43 (0.83)	3.60 (0.75)[b]
HDL-C	1.68 (0.39)	1.68 (0.38)	1.69 (0.40)	1.63 (0.36)	1.70 (0.43)	1.65 (0.39)
TAG	1.35 (0.78)	1.25 (0.60)	1.35 (0.68)	1.40 (0.66)[b]	1.35 (0.66)	1.38 (0.68)

Significantly different from baseline value for treatment group, [a]P<0.05; [b]P<0.01

Plasma cholesterol concentrations were lower at 4 and 8 weeks for both treatment groups relative to baseline, but this was only significant for the WG-R group at the highest level of intake. Conclusions: Incorporating WG foods made with rye into the diet was more effective in reducing blood cholesterol concentrations than consuming foods containing WG wheat. This may be due to the higher soluble fibre content of rye. *This study was funded by the UK Food Standards Agency (N05075).*

S108 12.10–12.30

Plasma alkylresorcinol metabolites as biomarkers of cereal fiber intake and breast cancer risk in free-living women

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Background: Alkylresorcinols (ARs) are shown to be good biomarkers of consumption of fiber-rich cereal products in man. It has been suggested that cereal fiber intake may reduce breast cancer (BC) risk. Objective: The aim of this study was to examine whether plasma AR metabolites could be used as biomarkers of cereal fiber intake and BC risk in free-living women. Design: Twenty omnivores, 20 vegetarians, 16 BC women

were recruited. Dietary intake (5-days record), plasma AR metabolites (3,5-dihydroxybenzoic acid: DHBA and 3-(3,5-dihydroxyphenyl)-1-propanoic acid: DHPPA) and plasma enterolactone (3-days plasma sample) were measured. The groups were compared using non-parametric tests for all variables. The relation between plasma AR metabolites and fiber intake were examined using partial correlation. Results: We observed that plasma DHBA ($p = 0.007$; $p = 0.031$), DHPPA ($p = 0.021$; $p = 0.012$) and cereal fiber intake ($p = 0.007$; $p = 0.003$) were significantly lower in BC group than in vegetarian and omnivore groups, respectively. We also found a significant ($p < 0.01$) correlation between cereal fiber intake and both plasma AR metabolites. Conclusions: We could conclude that plasma AR metabolites can be used as biomarkers of cereal fiber intake and BC risk in free-living populations and in epidemiologic studies. This novel approach will aid in studies on the association of cereal fiber intake and BC and other diseases.

Parallel Session 2 • Thursday, March 26, 2009 09.00–12.30

Grain properties and technologies; sensory challenges of wholegrain foods

Chairs: Kaisa Poutanen, VTT, Finland; Beth Arndt, Conagra, U.S.A.; Aliette Verel, Kraft Foods-Biscuits, France

S201 09.00–0.930

Improving the content and composition of phytochemicals and dietary fibre components in European wheat varieties

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Although wheat is widely consumed in a range of whole grain and refined products little is known about the extent of variation in the contents and compositions of phytochemicals, and the extent to which these differences are determined by the genotype and the environment. We have therefore carried out an extensive wheat diversity screen as part of the EU FP6 HEALTHGRAIN. 150 bread wheat lines selected on the basis of their wide geographical origin and including old and modern types were initially grown together on a single site with 50 other cereals and analysed for a range of phytochemicals (phenolic acids, alkylresorcinols, tocols, sterols and folates) and dietary fibre components (notably arabinoxylans and βglucans).

Substantial variation was observed within the bread wheats, with total contents of phenolic acids in wholemeal flour varying by 3.6 fold, of alkylresorcinols by 2.8 fold, of folates by 2.4 fold, of tocols by almost 3 fold and of sterols by 1.4 fold. Similarly, the contents of βglucans in wholemeal flour varied by 1.5 fold, and of soluble arabinoxylans in flour and bran by 4.8 fold and 2.0 fold, respectively.

Further studies of 26 wheat and 5 rye lines grown on the same site for two further years and on three additional sites for a single year showed that substantial proportions of the differences in composition between lines were genetically determined, although environmental effects were also apparent. The application of whole genome mapping to the wheat lines is allowing the variation in composition to be associated with specific regions of the wheat genome. This will facilitate the development of molecular markers to allow plant breeders to select for varieties with enhanced health benefits.

This study was carried out by partners in HEALTHGRAIN Module 2 including Li Li, Rebeca Fernandez-Orozco, Jane Ward (UK), Vieno Piironen, Anna-Maija-Lampi, Tanja Nurmi, Laura Nyström (Finland), Per βman, Annica Andersson (Sweden), Zoltán Bedö, Mariann Rakszegi (Hungary), Danuta Boros, Anna Fraβ Wioletta Dynkowska (Poland), Kurt Gebruers, Jan Delcour, Christophe Courtin (Belgium), Quraishi Umar Masood, Jerome Salse, Catherine Ravel and Gilles Charmet (France).

S202 09.30–10.00

Grain fractionation revised for new healthy ingredients

Xavier Rouau, Joel Abecassis, Cecile Barron, Marc Chaurand, Youna Hemery, Frederic Mabille, Milena Martelli, Abdelkrim Sadoudi, Marie-Françoise Samson, Valerie Lullien-Pellerin
INRA, UMR 1208 Agropolymer Engineering and Emerging Technologies INRA-CIRAD-SupAgro Montpellier-Université Montpellier II, Montpellier, France

Cereal processes were long optimised for products containing only grain endosperm. So the milling technology has been improved over the centuries for the production of white flour or semolina as a major product exhibiting excellent functional and sanitary properties for second transformation. However, a large part of the bioactive compounds of the grain that are preferentially located in the outer layers is thus excluded from the mass cereal foods. The manufacture of whole grain products (or inclusion of whole bran in flours) constitutes a possible response to better exploit the grain nutritional potential but with some limitations. The breadmaking functionality of whole grain flours makes it difficult to manufacture diversified and appealing products for consumers. Also the outermost layers of the grains may contain some contaminants which are detrimental to the sanitary quality of the flours. At last, the bioactive compounds exhibit in general a poor availability as they are trapped in the cellular fibrous structures of the enveloppes. Revising the conventional grain fractionation processes in considering the properties and potential of all its different parts and tissues will aim at producing new healthy functional ingredients for cereal-based food products of high sensory quality. New tools designed to gain a better understanding of grain tissue structure and their behaviour upon processing are necessary to develop and optimize a new grain fractionation technology. For example, the combination of milling and debranning monitored by a grain tissue marker methodology can allow to tailor flours with different levels of peripheral layers inclusion, quantitatively and qualitatively. The by-products from the milling industry (brans) can be exploited also as a source of healthy ingredients. They can undergo different cracking diagrams using advanced technologies of grinding and separation, to result in concentrates of grain tissues or sub-fractions of contrasted functional properties with improved availability of bioactives.

S203 10.20–10.50

Comparison of sensory characteristics of refined and whole grain foods

Raija-Liisa Heiniö
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The market of health promotional food products is continuously growing especially in Western Europe, and not least in the group of cereal products. Whole grain products are regarded beneficial to health, and because of high fibre content whole grain foods fight also against obesity. Good taste is a main criterion of food choice and a salient requirement for a product to survive on competitive markets. Sensory characteristics of whole grain foods have not, however, received a lot of research attention.

Flavour is composed of a simultaneous perception of taste, odour and chemical stimuli. During eating flavour perception is determined by the nature and relative amount of volatile and non-volatile flavour-active components, their availability to the senses as a function of time, and the mechanism of perception. The perceived flavour of cereal foods depends also on chemical and physical binding of the flavour-active compounds within the starch/protein matrix. Eating is a dynamic process, and the profile of compounds in mouth changes as a function of time, when the food changes while chewed.

The difference in the flavour between refined and whole grain products is substantial, but what causes the difference? An explanation for cereal flavour has traditionally been searched from volatile compounds found

in the headspace of a product. The impact of non-volatile compounds on the cereal flavour has only recently been proved. Whole grain products include outer layers of the grain, which contain several non-volatile, flavour-active substances. As compared to refined products, challenges concerning the sensory quality of whole grain products are colour, taste and texture. Dark colour of rye and greyish colour of barley are suggested to be caused by polyphenols and carotenoids. Bitter taste may result from certain polyphenols, peptides and fatty acids. Lignocellulose, big particles and insoluble fibre often cause a hard and fibrous texture in a product.

Grains always require some kind of processing prior to consumption, and the flavour is mainly formed in processing. By applying various (bio) processing techniques - fermentation, germination, enzymatic treatments; milling fractionation, heat treatments - the flavour can be significantly modified.

S204 10.50–11.10

Increase the healthy components in bread and maintain its product quality

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Wheat is a rich source of healthy components such as fibres, micronutrients and phytochemicals, which are concentrated in the outer parts of the grain. Most consumers prefer products of refined white flour to whole grain products, because they perceive the textural properties of whole grain products to be less attractive. Understanding the adverse effects of the outer grain fractions on bread quality may enable the development of products rich in healthy components that are also attractive to the consumer.

In this study the nature of the adverse effects of wheat bran fractions on bread quality was studied. Two fractions of the bran, representing different tissue layers and of different compositions, were used. The particle size of the bran fractions was varied by milling, while keeping the composition constant. Bran fractions of various compositions were obtained by electrostatic separation. Bran fractions, either rich in cell contents or rich in cell wall materials were obtained. All fractions were added to white flour. Water addition was adjusted to obtain dough with a constant consistency and compensate for possible differences in water absorption.

Our results demonstrate that the adverse effects on bread quality are caused by negative effects of bran on gluten network formation. Bran components interact with the gluten network hindering the ability of the gluten to reaggregate. These findings explain the negative effects of bran fractions on dough mixing properties and bread making quality. The insight in the mechanism in which bran fractions affect bread quality provide clear avenues to increase the amount of healthy components in bread whilst maintain its product quality.

Acknowledgement: This work is financially supported by the European Commission's HEALTHGRAIN Project (FOOD-CT-2005-514008). It reflects the author's views.

S205 11.10–11.30

Use of xylanases and crosslinking enzymes to improve gluten network properties in whole grain wheat bread

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Whole grain cereal products are widely agreed to be health-beneficial. Although the health-promoting cereal foods are becoming more important in the food market, consumers still make purchase decisions mostly based on the palatability of the product. The challenge in the whole meal breadmaking is to overcome the deficient gluten network formation which is due to the presence of outer layers of grain, pericarp and aleurone layer. In particular, arabinoxylans (AX) influence negatively the gluten properties by changing the water distribution in the dough and also by having covalent interactions with gluten. Enzymes offer a tool to modify the sensory properties of bread. Hydrolysis of AX by endoxylanases improves the rheological properties of dough and bread via redistribution of water from AX to gluten and by increasing viscosity due to water insoluble AX solubilization. Enzymatic crosslinking can also have positive impacts in breadmaking. Crosslinking of gluten proteins or AX of wheat flour may enhance gluten properties and thus also the texture of bread.

In this work use of xylanases and the crosslinking enzymes transglutaminase, tyrosinase and laccase was examined with an attempt to improve the textural properties of whole meal wheat bread. In addition, digestibility of the breads was studied using a method combining chewing *in vivo* and treatment with pepsin *in vitro*. The oxidative enzymes, laccase and tyrosinase, as well as xylanases improved bread instrumental and sensory texture, whereas the effect of transglutaminase was detrimental in the conditions studied. Furthermore, although there were not significant differences in the amount of large bread particles after *in vitro* digestion, the micrographs of the large particles showed enzyme dependent differences in swelling of starch granules, aggregation of starch and formation and rigidity of protein network.

This study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

S206 11.30–11.50

Factors influencing technological properties of high-fibre oat ingredients

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Oat is an optimal raw-material for health-promoting foods. Soluble oat fibre, βglucan is well-known for its cholesterol-lowering and glucose attenuation properties. In addition to the soluble fibre fractions, oats contains insoluble fibre, high amount of lipid with nutritionally beneficial fatty acids, proteins rich in valuable amino acids, and unique phenolic compounds, like avenanthramides. Furthermore, oat can be included into the gluten-free diet. Production and use of high-fibre oat fractions is, however, technologically challenging due to susceptibility of beta-glicans to depolymerization and formation of viscous gels at very low concentrations. Furthermore, oat lipids can be hydrolysed during processing and form rancid off-flavours.

We have studied the effect of lipid removal on the properties of oat flour. Supercritical carbon dioxide extraction was used to remove lipids. We have used this low-fat oat ingredient in several applications, like extrusion, milling and following classification, and as a baking ingredient in sourdough baking. The results showed that lipid removal changed totally the behaviour of oat in a fractionation process aiming to concentrated βglucan fractions and resulted ingredients of higher βglucan concentration than typically achieved by a dry-fractionation process. In addition to fibre fraction, protein and starch fractions with high purity and stability were attained.

The results showed that supercritical extraction changed the enzymatic activity of oat ingredients, and furthermore, that these changes in enzyme activity were critical in a baking process. Baking of whole meal oat flour is a challenge due to the lack of gluten proteins as well as high content of β-glucan, leading easily to tight, moist and gummy breads.

We studied the effects of fermentation on dough rheology using native, heat-treated and supercritically extracted oat flours. The endogenous enzyme profile, as well as lipid content, were very different in fractions, the lowest βglucanase and alfa-amylase activity occurring in heat treated fractions. On the other hand, supercritical extraction seemed to have a largest effects on lipolytic and oxidative enzyme profiles. In subsequent fermentation with lactic acid bacteria and baker´s yeast, clear differences in fermentability and rheological properties were demonstrated, due to differences oat fibre fractions.

S207 11.50–12.10

Biofortification of wheat grain with zinc by using fertilizer strategy

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Zinc (Zn) deficiency is a growing public health problem globally, particularly in the developing world. High and monotonous consumption of cereal-based foods with low amounts and availability of Zn appear to be main reason for widespread occurrence of Zn deficiency. Nearly, one-third of world population is under risk of Zn deficiency. Recent estimates indicate that Zn deficiency together with vitamin A deficiency is responsible nearly for 11% of the deaths of children under than 5 years in the world.

Providing Zn-enriched cereals has been discussed as an effective intervention to alleviate Zn deficiency-related public health problems. Among the strategies being discussed as a major solution to dietary Zn deficiency problem, plant breeding strategy appears to be a cost-effective approach useful in improving Zn concentrations in grain. The breeding approach is, however, a long-term process and depends on the size of soluble Zn pools in soils. Application of Zn fertilizers (e.g., agronomic biofortification) offers a rapid solution to the problem, and represents useful complementary approach to on-going breeding programs. Field trails on various locations by using different Zn application methods showed that Zn fertilizer strategy represent a very promising and rapid solution to the problem. Depending on the locations, Zn concentrations of wheat grain could be increased by 2- or 3-fold by soil and/or foliar applications of Zn fertilizers. Zinc fertilization was also effective to improve endosperm Zn concentrations. Compared to ZnO and ZnEDTA, ZnSO4 was the most effective Zn form in improving grain Zn. It was important to determine that N fertilization stimulated Zn loading into seeds. Screening studies on large number of wheat germplasms showed existence of a very close positive relationship between Zn and protein concentrations of seeds/grains. The results available indicate that application of Zn fertilizers is a very relevant and effective way to maximize grain Zn accumulation and to contribute to nutritional quality of cereal-based foods.

S208 12.10–12.30

Enzymatic modification of flour components in whole grain bakery products

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It is well documented, that increasing the level of fibre in our diet is beneficial for our general health. The positive effects such as lower occurrence of coronary hearth disease and cancers of the lung, colon, oesophagus and stomach is scientifically documented. This has lead to different health claims in Europa and US on whole grain products. However, producing quality bread products that meet the health claim is both challenging and essential. It is important to succeed in producing whole grain / high fibre products that meet the health claims without deviating from the already accepted product quality parameters. In this study we have evaluated use of wholemeal flour as well as milled fractionation-reconstitution experiments to study the effect of different wheat fractions on the bread making process of whole grain products. As expected, we find that the increased level of fibre material in this type of product is detrimental to production and quality parameters. However, modifying the whole grain material, using enzymes, we have been able to turn some of the whole grain flour fractions into functional ingredients in situ, improving both the process and product quality significantly. Experience obtained by improving the whole grain type of bread, through wheat fibre modification, can be implemented into a range of bread applications.

Poster Session 1 • Thursday, March 26, 2009 14.00–14.45

P1P01

Potent natural immunomodulator, water soluble polysaccharide fractions with anticomplementary activity in two staple cereal foods of the world: rice and wheat

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Background: There is considerably recent interest in the physiological effects of foods on health. Research has focused on the biological effect on the immunological system, as substances related to human defence systems are expected to be in staple cereals. The aims of the presented study were to investigate whether water soluble polysaccharide fractions in wheat have similar anticomplementary activity to that found in water soluble polysaccharides found in rice, and to distinguish between real complement inhibitors and complement activating substances. Results: As compared polysaccharide isolated from the medicinal herb *Glycyrrhiza uralensis*, anticomplementary activity of the rice polysaccharides showed similar potency, but that of wheat polysaccharide did not. By means of varying the preincubation time with complement, the rice polysaccharides were identified as a stimulator of both the classical and alternative pathway of complement activation (humoral immunity). Conclusion: Non amylaceous water soluble polysaccharide fractions in cereals do not necessarily have the similar activity, whereas it is new finding that staple cereals include this immunomodulating activity which is positively related to health.

P1P02

Antioxidant activity of fermented soybeans in linoleic acid emulsion model

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Intensive studies have been carried out to explore antioxidants from various natural sources mainly due to increasing health concern of using synthetic antioxidants in foods. Soybeans are not only a good source of basic nutritional compounds such as protein and oil but also of phytochemicals like isoflavones and phenolic acids which have antioxidant properties. It is reported that antioxidant activities are significantly higher after fermentation process. A simple model, i.e linoleic acid emulsion, was used to observe the antioxidant activity of fermented soybeans.

The effects of aqueous ethanol extract of soybeans fermented with *Aspergillus oryzae* on linoleic acid oxidation were examined in 60ºC at pH 4.5 and 7 in phosphate buffer over 12 h. The autoxidation was monitored as a function of time and extract concentrations (0.1 mg/ml to 10 mg/ml) by measuring the absorbance of different oxidation products, namely conjugated diene and hydroperoxide as the primary products and the malonaldehydes as the secondary. The different methods were

necessary due to various capability of antioxidant in inhibiting oxidation process.

The linoleic acid emulsion demonstrated an autoxidation process at the outset of the incubation process. The absorbance of the oxidation products increased following the extension incubation time. In general, 2 mg/ml extract extended the induction period of oxidation process up to 12 h. The results suggested that the fermented soybeans extract showed good inhibitory effects in both primary and secondary products. However, there was no different oxidation inhibitory impact between the two pH values studied. The outcome of this research suggest that fermented soybeans extract might be a good substitute to synthetic antioxidants, hence further research is to continue with more complex systems and eventually with systems comparable to that of food composition

P1P03

Do short chain fatty acids have an anti-inflammatory, and vascular protective effect on endothelial cells?

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Cardiovascular disease (CVD) is one of the major causes of mortality and morbidity in the UK and other Westernised countries. There is growing epidemiological evidence for an inverse relationship between diets high in whole grains and CVD risk. However, the mechanism underlying this relationship remains unknown.

Currently we are carrying out human nutrition intervention trials involving whole grains and supporting these with cellular models of whole grain intervention. By treating primary human abdominal aortic endothelial cells with fermentation breakdown products of whole grains, Short Chain Fatty Acids, we hope to investigate the relationship at the cellular level. Endpoints include endothelial cell products such as von Willebrand Factor, Tumour Necrosis Factor alpha, Interleukin 8, Tissue Plasminogen Activator 1 and Nitric Oxide, factors associated with systemic inflammation, a condition implicated in CVD initiation and progression. Currently we are at the stage of analysing samples and we will present data from those analyses.

P1P05

Composition of lignans in biofluids, tissue and excreta of pigs fed fibre-enriched rye bread

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Epidemiological and interventional studies suggest that a diet rich in lignans may be protective against the development of chronic of diseases such as certain cancers and cardiovascular disease. With improved analytical methods new plant lignan precursors of enterolignans have recently been reported, widen our knowledge on dietary exposure to lignans. Plant lignans metabolism is largely unknown.

To elucidate and quantify the metabolic fate of the different plant lignans, we fed pigs with a high-fibre, high-lignan rye-based diet for up to 10 week and analysed the content of both plant- and enterolignans in diet, faeces, urine, blood, bile and selected tissues.

The rye diet contained 105 nmol total lignans per gram dry matter of which syringaresinol was the dominating lignan, accounting for 60 percent of the total analysed content. Most lignans detected in blood were in the form of enterolactone, but a 23% of the lignans taken up by the portal vein was in the form of plant lignans, while the proportion was slightly lower (14–17%) in systemic arterial and venous blood. Only enterolactone was detected in tissues such as colon, liver, breast and brain. Of the lignans eliminated in faeces, 43% were in the form of plant lignans representing both non absorbed and partially fermented plant lignans as well and absorbed plant lignans undergoing enterohepatic circulation and further elimination. The majority of lignans excreted in urine was in the form of enterolignans, but up to 11% were in the form of plant lignans. Bile contained large concentrations of lignans, and the proportion of plant lignans was as high as 77%. The reason for the high concentrations of plant lignans in bile is not known, but it may be speculated that some enterolignans are reconverted to plant lignans in the liver before excretion to the intestine by enterohepatic circulation, and/or a discrimination of lignans takes place in the liver, diverting plant lignans towards biliary excretion into the intestine. To what extent the high concentration of plant lignans in bile reflects a protective mechanism and is a consequence of systemic overload requires further investigation. The implications of systemic exposure to plant lignans compared to the enterolignans remains to be elucidated.

P1P06

Modulation of nuclear factor kappa B (NF-κB) by phenolic components from cereal grains

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Convincing evidence suggest that consumption of whole grains lowers risk of diseases such as cardiovascular disease, diabetes, obesity, hypertension and gastrointestinal cancers. The focus in such studies has been directed towards the connection between the positive effects of whole grain diet with its content of dietary fibre on the human health. In addition to dietary fibre, whole grains contain minerals and phytochemicals including phenolic acids. Phenolic compounds possesses antioxidant properties that may help in protection against reactive oxygen species (ROS) involved in different diseases. The content and diversity of antioxidants in fruits and vegetables is high, however it has been shown that phenol content in cereals and their antioxidant activity levels are comparable with fruits and berries. Cereal grains contain both extractable (free) as well as covalently linked phenolics. To obtain free and bound phenolics a successive extraction must be performed in combination with a hydrolytic step.

The transcription factor nuclear factor kappa B (NF-κB) play a critical role in stress-, immune- and inflammatory responses. Also, NF-κB is identified as a promising therapeutic target both in cancer and chronic inflammation. We used monocytes stably transfected with a NF-κB-luciferase reporter construct in testing cereal extracts for NF-κB modulators. Our aim was to identify phenolic compounds from cereal grains which could induce basal NF-κB activity to produce preconditioning effect, or inhibit disease related NF-κB activity.

Results of LC-DAD-MS analysis shows that phenolic acids are concentrated in bound form in cereals. Oat had the highest content of phenolic acids followed by barley and wheat. The content of free phenolic acids was low.

When testing free and bound phenolics from oat, barley, wheat and buckwheat for their ability to induce basal NF-kB activity or inhibit lipopolysaccharide (LPS)-induced NF-κB activity we observed that free phenolics from oat and barley induced NF-κB activity, while bound phenolics from all cereals except buckwheat inhibited LPS-induced NF-κB activity. These results indicate that oat and barley contain compounds that modulate NF-κB activity.

P1P07

Effects of the regular consumption of wholemeal wheat foods on cardiovascular risk factors in healthy people

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Background: The intake of wholemeal foods is consistently associated with reduced risk of type 2 diabetes and cardiovascular diseases in epidemiological studies, although the mechanisms of this association are unclear. Aim: To compare in healthy subjects the metabolic effects of a diet rich in wholemeal wheat foods vs. one based on the same products in refined form. Methods: Fifteen healthy individuals (12M/3F), mean age 54.5±7.6 yrs, BMI 27.4±3.0 kg/m^2 (M±SD), participated in a randomised sequential crossover study. After two-weeks run-in, participants were randomly assigned to two isoenergetic diets with similar macronutrient composition, one rich in wholemeal wheat foods and the other with the same foods but in refined form (cereal fibre 23.1 vs. 9.8 g/die). After the two treatment periods (each lasting three weeks) plasma glucose and lipid metabolism, antioxidant activity, acetic acid, magnesium, adipokins, incretins and hs-c-reactive protein (hs-CRP) were measured at fasting and for 4 h after a standard test meal (kcal 1103, Protein 12%, CHO 53%, Fat 35%) based on wholemeal or refined wheat foods, respectively. Results: After the two diets there were no differences in fasting nor in postprandial plasma parameters responses; only glucose was slightly but significantly lower at 240 minutes after the refined wheat food meal compared to the wholemeal wheat food meal. Conversely, after the wholemeal diet both total (-4.3%; p<0.03) and LDL (-4.9%; p<0.04) cholesterol levels were lower than after the refined wheat diet at fasting. A similar reduction in post-prandial plasma cholesterol levels was observed up to 240 min after the wholemeal cereal diet. Conclusions: Consumption of wholemeal wheat foods for 3 weeks reduces significantly fasting and postprandial plasma cholesterol as well as LDL cholesterol levels in healthy individuals without major effects on glucose and insulin metabolism, antioxidant status and sub-clinical inflammation markers.

P1P08

Using food frequency questionnaires or food diaries to investigate the impact of dietary intervention with prescribed amounts of wholegrain foods on estimated nutritional intake (the WHOLEheart study)

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Background: Increased consumption of wholegrain (WG) foods has been linked to reduced disease risk. The impact of interventions to increase wholegrain food intake has not previously been measured in a large-scale randomised, controlled trial.

Methods: 316 overweight participants (age 18–65y, BMI>25 kg/m^2 but otherwise healthy) who habitually consumed <30 g WG/day were recruited in 2 UK study centres (Newcastle and Cambridge). Participants were randomised to 3 groups: Control (no dietary change), Int. 1 (consumed 60 g WG/day for 16 weeks) and Int. 2 (consumed 60 g WG/day for the first 8 weeks, followed by 120 g WG/day for a further 8 weeks). Dietary intake was assessed by food frequency questionnaire (FFQ) in all participants at weeks 0, 8 and 16. A subset of participants (25%) filled in 4-day food diaries as a comparison to FFQs. Nutrient intake and food frequency for Int. 1 and Int. 2 were compared with the Control group by 2-sample Wilcoxon-ranked sum test. Results: The Spearman correlation values for daily macronutrient intakes (i.e. total energy, fats, proteins, carbohydrates and dietary fibre) ranged from 0.4 – 0.47 (P<0.0001 for correlation, although mean macronutrient intakes tended to be higher in FFQs. The WG intervention resulted in a significant increase (all P<0.001) in intake of dietary fibre (a median change of over 4.5g/day in intervention participants vs. control), B vitamins and some minerals (Fe, Mg, Mn and Zn). The WG intervention also resulted in >5% increase in carbohydrate intake (over 14g/day (p<0.007) and higher intakes of total energy and sodium at some time points. At the highest WG intake (i.e. Int. 2 at week 16) the frequency of fruit consumption was reduced (P=0.045).

Conclusions: The provision of wholegrain foods led to wider changes in dietary intake, including a significant increase in dietary fibre, but also in sodium intake. *This study was funded by the UK Food Standards Agency (N02036).*

P1P09

Whole-grain consumption improves arterial stiffness in young, adult males

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Evidence from epidemiological studies suggests that diets rich in whole grains can reduce the risk of cardiovascular disease (CVD). However, there is very little evidence from randomised control trials to support this beneficial effect, particularly with respect to clinical endpoints of CVD such as arterial stiffness and endothelial dysfunction. Research is currently underway examining the potential metabolic effects whole grains may have on CVD in a classically 'at risk' group. However, in order to extrapolate these results within a typical population, it is important to determine the impact that whole grains may have on a relatively younger, healthier group also.

To quantify these potential effects, this study was set-up in order to assess the physiological impact whole grains may have on a low CVD-risk population, using the following outcomes: arterial stiffness, ambulatory blood pressure, lipid profile, inflammatory markers, glycaemic and insulinaemic responses, and anthropometrics.

Twenty-five healthy males, aged 21-26yrs participated in a 3-way, parallel dietary intervention study. In addition to their normal dietary patterns, participants consumed two whole-grain rolls (containing 48g of intact whole-grain), two milled grain rolls (containing 48g of crushed grain) or two isocaloric refined grain rolls (control) per day for 8 weeks. Pre and post-intervention, the following clinical outcomes were recorded: arterial stiffness (Pulse Wave Velocity, PWV), 24hr-ambulatory blood pressure, lipid profiles, inflammatory markers, glycaemic and insulinaemic responses, and anthropometrics.

After 8 weeks, the whole-grain intervention group showed a significant reduction in central PWV (p=0.02). No significant changes were detected in the control group or the milled grain group. No significant changes were detected for anthropometric parameters. Ambulatory blood pressure, serum lipid, inflammatory markers, glucose and insulin profiles are currently being analysed.

These results demonstrate for the first time a positive influence of whole-grains on CVD risk using an established, reproducible clinical endpoint. Since changes were achieved in a small group at low-risk of CVD, the data provides good justification for a cardio-protective role of whole-grains. Further research is currently underway to develop research within differing age groups and categories of CVD risk.

P1P10

Application of a non-targeted UPLC-TOF-MS metabolite profiling approach for the analysis of the biochemical effects of high fibre rye *versus* wheat bread intake on human plasma profile

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Consumption of whole grain foods is convincingly associated with reduced incidence of cardiovascular disease and diabetes. Rye (*Secale cereale*, L.) is a major bread grain in Northern Europe, and has traditions of use as whole grain bread. Identification of the biologically active molecules and factors, as well as mechanisms behind the improved insulin economy revealed in clinical studies is still lacking. Ultra-performance liquid chromatography time of flight mass spectrometry (UPLC-qTOF-MS) offers a tool for metabolomic approaches in order to explore the complex metabolic effects of diets, nutrients and non nutrients. In this study, we aimed at elucidating the "*whole grain rye fingerprint",*ie. specific metabolites characteristics of rye food intake and/or endogenous compounds reflecting a biological action of the rye intervention. Fasting plasma samples from healthy postmenopausal women (n = 39; BMI = 26.8 ± 0.5 kg/m^2) were obtained from a 2 x 8 wk randomized crossover intervention with high-fibre rye bread (17% of dietary fibre) and low-fiber wheat bread (2.8% of dietary fibre) and 8-wk washout period. Plasma samples were analyzed by non-targeted UPLC-qTOF-MS metabolite profiling using a Waters Acquity UPLC instrument coupled to Micromass Q-TOF Micro with an electrospray source operating in positive and negative modes. Search of markers was carried out by applying Micromass MarkerLynx (v 4.0 SP4 integrated to the MassLynx 4.0 software).

Metabolites were identified according to their exact mass compared with those registered in the Human Metabolome Database, as well as to those of expected metabolites previously described in the literature. In addition, ChemSpider and SciFinder software were used to suggest tentative metabolite chemical structures derived from the cereal intervention. The preliminary multivariate analyses did not show clear differences due to the rye vs. wheat intervention, but subtle differences in specific metabolites were observed after the cereal intervention periods. Further analysis of the data is in progress. *This work is part of the Nordic Centre of Excellence program in the area of nutrition, food and health, within the projects SYSDIET- Systems biology in controlled dietary interventions and cohort studies, and HELGA- Whole Grains and Health.*

P1P11

Comparison of traditional and physicochemically modified wheat bran with enhanced bioactive component solubility on body composition and energy expenditure in a hypercholesterolemic hamster model

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Wheat bran contains a diverse collection of macronutrients, micronutrients and bioactive components, including those thought to have a role in reducing the risk of chronic disease. Bran's bioactive components include fibre and constituent phytochemicals such as phenolic acids, folate, lignans, sterols, and alkyresorcinols, all of which are largely insoluble and believed to have limited bioavailability until passage through the large intestine. Presumably, if the solubility of wheat bran could be enhanced by pre-treatment, its biological impact associated with constituent bioactives, would also be enhanced. We used a hypercholesterolemic hamster model to study the effects, on circulating lipids, body composition and energy expenditure, of NovaBran™, a physicochemically modified wheat bran developed in our laboratory with enhanced antioxidant activity and increased levels of soluble fibre and iron. Forty-five Syrian golden males were randomized into three groups and fed for 28 days a basal control diet or the control diet supplemented with 10% traditional wheat bran or NovaBran, at the expense of corn starch. Primary outcomes were plasma total, HDL and non-HDL cholesterol, triglyceride and glucose concentrations. Secondary outcomes included weight gain, food intake, oxygen consumption and body composition measured by dual energy X-ray absorptiometry. Neither traditional bran nor NovaBran diets affected plasma lipid concentrations compared to controls, however plasma glucose was lower (P = 0.07) in the NovaBran group (6.9 mmol/L) compared to controls (8.5 mmol/L). Animals supplemented with NovaBran had lower percent body fat (49.8 vs 53.4%; P = 0.02) and higher percent lean mass (47.2% vs. 44.1%; P = 0.02) compared to controls despite no differences in food intake or weight gain over the 28 days. Oxygen consumption was also higher in the NovaBran fed animals (2.2 vs. 1.6 ml/g lean body mass; P = 0.01) compared to controls, possibly due to the higher lean body mass. In conclusion, results of this animal trial using hypercholesterolemic hamsters indicate that wheat bran altered to increase bioactive component extractability/solubility had different and favourable physiological outcomes compared to unmodified bran and a control diet without wheat bran. Consumption of NovaBran may be an effective dietary strategy as needed to reduce adiposity and increase energy expenditure.

Poster Session 2 • Thursday, March 26, 2009 14.45–15.30

P2P01

Changes of wheat flour, dough and bread quality with lupin addition

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The use of lupin-wheat flour for bread making purposes and consumption are new in the Czech Republic. The study investigated properties of dough and bread from composite flour made by mixing lupin flour to white wheat flour at rates of 0, 10 and 20% (w/w). Rheological properties of flours were tested by means of farinograph and amylograph (Brabender, Germany) and alveograph (Chopin). The dough prepared with salt, sugar, fat and yeast behavior was described according to fermentograph SJA (Sweden), maturograph and oven spring (Brabender, Germany) tests. Baking quality parameters as specific volume of bread, loaf shape, sensory evaluation and crumb penetration were conducted. Incorporation of lupin flour in the wheat one increased water absorption and dough development time. Alveograph ratio P/L decreased more than twice, but W value lowered nearly about 20%. Maximum at amylogram curve dropped approximately on half value - from 840 AU to 400 AU. Also fermentograph dough volume, optimal proofing time and dough stability during fermentation periods decreased in regard to the lupin amounts addition. Specific bread volume significantly increased with lupin fortification but sticky dough during baking test was found at higher rates. Incorporation of lupin in the dough had a positive effect on the crumb colour. Flavour, aroma and overall acceptability of bread were not influence by lupin flour replacement.

P2P03

Antifungal effect of *Eucalyptus globules* essential oil on growth of moulds causing cereal grains spoilage

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Cereal grains form an excellent substrate for the growth of moulds, where the fungal flora of grains during storage forms a significant factor of deterioration and secretion of mycotoxins.

From the 118 strains isolated from cereal samples, *Aspergillus* and *Penicillium* species were the most dominant followed by *Fusarium* and *Trichoderma*. In contrast, the mucorales were the least abundant species found. Among the strains isolated, seven were selected for the study of the antifungal effects of essential oils extracted from *Eucalyptus globules*. The yield of essential oils from the plant material was about 0.64% of essential oil.

The species of fungi were classified by descending order according to their sensitivity toward this essential oil at a rate of 50µl/20ml of PDA medium as follows: *Trichoderma* sp., *Rhizopus stolonifer*, *Fusarium oxysporum*, *Penicillium* sp., *Alternaria* sp., *Aspergillus niger* and *Aspergillus flavus*.

The results suggest that the essential oil of *Eucalyptus* might be suitable for use as an alternative antifungal agent to chemical products used in the structures of storage cereals.

Keywords: cereals, moulds, essential oil, *Eucalyptus globulus*, antifungal effect.

P2P04

Softkorn, tender grains enriched with a mild naturally fermented sourdough taste

Stefan Cappelle

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Based on the latest studies on consumer trends in food, increasing importance of the natural and healthy aspects of food can be noticed. For baked goods, the popularity of whole grain is rising quickly. Next to the fact that people are more and more health conscious, they definitively do not want to compromise on the taste of their healthy food. Eating healthy food should be at the same time a delighting sensorial experience while it makes you feel better.

Softkorn is an innovative product based on whole grain and matches with the current consumer demands. During the entire process, the grains in the Softkorn are kept intact. As such the 'whole grain' concept can be visualised in the final product as a healthy inclusion of an entire grain. This visual aspect of Softkorn is very teasing for the consumer.

The key process step during the production of Softkorn is the cooking of the grains in a mild natural sourdough. This has multiple advantages for the final baked product.

First of all, the grain becomes tender and the starch in the grain is saturated with water. So the consumer will no longer break a teeth biting on a hard raw grain. Instead, the Softkorn offers tender grains and while chewing, the mild sourdough taste is released. More taste in a natural way, that is the way to satisfy the consumer needs.

Finally, as the Sofkorn grains are saturated, there is no longer a migration of water from the crumb of the bread towards the grains. The crumb softness is preserved for a long period and the bread at home will not stale so quickly.

The baker is also not forgotten in this concept. Softkorn will build on the creativity of the baker. He will decide how much Softkorn will be added on the dough. Multiple grain types are available as well as multiple sourdough tastes. So only there where the baker's imagination ends, are the limits of the Softkorn.

P2P05

Whole grain wheat flour functionality assessed by alveograph analysis

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Commercial whole grain wheat flours have been marketed recently with reduced particle size. These flours exhibit poor food processing performance in baked goods, especially in cookie, cracker and cereal production, due to fine grinding of the whole grain to particle sizes ≤150 µm, resulting in starch damage. Commercial stabilization used to extend storage stability is commonly performed, and can result in starch gelatinization. Therefore, the functionality of the flours is compromised, having a big effect in dough machinability and cookie spread, for example. The need to assess whole grain wheat flour functionality with a predictive tool exists. Alveograph analysis was chosen because it is a widespread rheological test used in the milling industry, which has been found to correlate to early stages of baking of low-extraction wheat flours. A new version of the AACC International 54-30 method was developed by Chopin Technologies in which the mixing times and percent hydration were modified to achieve bubble inflation of whole grain wheat flours. Commercially-available whole grain wheat flours of different wheat sources and varying particle sizes were analyzed, resulting in a range of alveograph parameters (P, L and W). These measurements were also correlated to predictive tests such as solvent retention capacity and cookie bake spread test, which give an enhanced profile of whole grain wheat flour functionality, as well as flour performance during commercial production of baked goods.

P2P06

Mixolab characterization of flour quality according to their end use

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The quality of flour is judged on the basis of its end use. Mixolab is a polyvalent dough mixer which is used to determine the rheological and gelatinization properties of flour. A complete characterisation of the flour is possible in a single test. The objective of this study is to determinate the ability of the Mixolab to discriminate samples as a function their end use. For doing so, the profiles of different flours with different end uses are defined according to 6 functional criteria given by the Mixolab (Profiler): water absorption, kneading behaviour, gluten strength, maximum viscosity, amylase activity and retrogradation. Each criterion is noted with an index value ranging between 1 and 9. Each sample is characterized with a Mixolab index composed of the value of the 6 criteria. 5 sample of standard baguette flours, 5 samples of pan bread flour and 5 samples of biscuit flour are analysed on Mixolab (Standard protocol). The minimum and the maximum Mixolab index is (5-46-577; 6-57-688) for pan bread, (5-13-221; 6-34-432) for baguette and (1-16-777; 2-57-888) for biscuit. Regarding only the water absorption index, the baguette and the pan bread type of flour are not different. But the information provided by the entire profile completely discriminate the 3. This study proves that the Profiler tool of the Mixolab system is an efficient quality control tool for the milling and baking industries.

P2P07

Relationship between bread characteristics and the Mixolab

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End-product quality is always the results of the raw material quality (i.e flour quality) and the process. We should also pay attention that customer's habits and culture also define the product quality. If one considers standard white pan bread; customers will ask for a good shape, a good flavour, good colour, fine and regular alveols, soft crumb and good

shelf life. Considering this pan bread always produced under the same process conditions, flour functionality plays a critical role in the bread formation.

The water absorption will be influenced by several components (proteins, starch, damaged starch, and pentosans).

Dough mixing characteristics influence the dough matrix creation, air incorporation forming nuclei that will be the base of future alveols.

Gluten characteristics and particularly hydrogen bonds between chains and influence dough behaviour during the first phase of baking, influencing the volume.

Starch quality and possibility to gelatinise (this gelatinisation is limited in dough systems where water is not fully available) will influence the crumb softness.

Amylasic activity, will influence gas production, bread volume, cell diameter, colour, crumb stickiness. Finally, starch retrogradation will influence the bread shelf life.

Fifty wheat flour samples with bread volume between 1071cm^3 and 1999cm^3, Bake absorption between 55.9% and 61.3% and dough scoring between 22 and 97 are analyzed with the Mixolab. Prediction model based on the data given by the Mixolab (times, torques and temperatures) have been developed for these 3 parameters. The obtained predicted models show very good performances. 98% of volume predictions, 100% of bake absorption and 98% of dough scoring are inside the reproducibility limits of the standard.

The Mixolab can be used to determine the bread characteristics of wheat flour samples.

P2P08

Influence of bran particles size and solvent type on the efficiency of lipids extraction from wheat bran and the nutritional potential of the extracted oils

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The current wheat milling process aims at recovering white flour and discarding bran and germ. Bran is a milling by-product that contains 20–30% of wheat grain lipids. Bran lipids are responsible for the formation particles agglomerates during bran processing. It could therefore be interesting to extract these lipids, to make bran processing easier, and use separately the extracted oils if they were found to be worthwhile. While rice bran oil and wheat germ oil are used in food, cosmetic, and pharmaceutical industries, wheat bran oil is less studied and not so much used. The objectives of this work were to evaluate the nutritional quality of oils extracted from wheat bran and wheat aleurone, and to study the influence of solvent and particle size on lipids extraction yields and oils composition. Wheat aleurone oil exhibited a composition very similar to wheat bran oil, confirming that the aleurone concentrates most of bran lipids. Wheat bran oil and wheat aleurone oil were also found to have a fatty acid composition very close to that of wheat germ oil (65% poly-unsaturated, 17% mono-unsaturated, and 17% saturated fatty acids), but quite different from that of rice bran oil (34% PUFA, 44% MUFA, and 21% SFA). Particles size of samples influenced the extraction yields: the finer the particles, the higher the yield, for both bran and aleurone. Only 38% of total lipids were extracted from bran when it was not ground, and oils composition were different for finely ground and intact bran: finely ground bran oil contained 77% triglycerides and 18% free fatty acids, while intact bran oil contained 32% TG and 59% FFA. In the case of intact bran, only the lipids located at the particles surface were extracted. Due to their position, these lipids may have been hydrolyzed during bran storage, leading to a higher FFA content. The extraction solvent influenced lipids extraction speed and oils composition. While 4h were needed to extract 85% of the total lipids of finely ground bran by using only supercritical CO_2, only 45 minutes were needed when 2% isopropanol were added to modify the solvent polarity. This polarity increase also enabled to extract more sterols, tocopherols and tocotrienols from bran.

P2P09

Effect of fermented and non-fermented barley and oat on dough rheology and bread quality

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Barley and oat are considered beneficial for human consumption, mainly due to their high contents of soluble fiber, in particular βglucan. In addition to that, oat has also a nutritionally balanced amino acid composition and a high content of unsaturated fatty acids. The health beneficial effects of oat and barley βglucans have developed much interest in recent years. The documented health benefits of oat and barley have led to an increasing desire to use these cereals as ingredients in food for human consumption for example in bread. However due to their lacking ability to form viscoelastic dough with the capability to retain gas and produce leavened bread, barley and oat are not commonly used for bread production.

The deteriorating effect of oat and barley flour on wheat bread quality, especially due to reduction of bread volume and increase in crumb firmness, limits the incorporation of those flours in wheat bread formulas.

The use of sourdough in wheat bread production has been shown to improve flavour, texture, shelf life and bread volume. Sourdough is especially beneficial to the production of high fiber wheat bread. In addition the organic acids in sourdough bread have been shown to lower the glycaemic response. Sourdough might therefore be a tool to improve the quality of barley/oat composite breads.

In this study different fermented (with lactic acid bacteria) and non-fermented barley and oat flours were used to substitute wheat flour. The resulting changes in dough rheology were investigated and related to changes in hearth bread characteristics.

The substitution of wheat flour with oat/barley flour increased water absorption and decreased dough stability, dough extensibility and dough resistance to extension. This resulted in a reduction of bread volume and increase in crumb firmness. The use of oat/barley sourdough decreased water absorption and dough extensibility and increased dough resistance to extension. Bread baked with sourdough got increased form ratio (bread height/ bread width) but the use of sourdough did not affect volume and weight. Use of barley and oat sourdoughs improved the quality of barley and oat composite hearth bread, and can be a way to increase human consumption of oat and barley.

P2P10

Barley breeding and its potential impact on human health and nutrition

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The frequency of heart disease, colorectal cancers, type II diabetes and obesity are steadily increasing in westernised societies, and also rising in developing countries. Such diseases are causing major public health problems, resulting in these issues becoming a high priority for governments worldwide. A viable approach for improving public health is to make appropriate changes to food products and give them substantiated health benefits while retaining consumer appeal. Consequently, cereal grains have become prime candidates for such modifications. Numerous studies have indicated even the smallest alterations in grain composition (i.e. starch, beta-glucan and fibre) can deliver significant health benefits once integrated into food.

Processing techniques such as pearling, milling, flaking and micronization allow barley to be utilised in a variety of food products. Availability of hulless barley can provide manufacturers with a fast cooking grain (whole or pearled), excellent pearling and flaking quality and a higher soluble fibre (or beta-glucan) content. The advantage of using hulless barley is two-fold: a) pearling is not required to make the grain edible, and b) by using the intact kernel, the full benefit of the nutritional components is achieved. Hulless barley breeding at the Waite Campus specifically aims to develop hulless types with these high value-added traits for the food industry.

We have compared the physical grain quality, pearling, baking and flaking quality of Australian waxy hulless barley with other hulless and covered barleys. These quality parameters have been investigated to a lesser extent for high amylose hulless barley. The quality attributes of these hulless barleys will be discussed in the context of potential products and market opportunities. Recent progress in improving the agronomic performance of hulless barley to support economically viable crop production will also be presented.

P2P11

Monitoring the dynamic density of fermenting dough using novel methodologies

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Dough aeration and the changes that occur during proofing and the early stages of baking have long been highlighted as important aspects of the breadmaking process. In recent studies, the aeration of dough has been studied by monitoring its density; a technique which was proven to be sensitive and useful in studying the aeration of flours of different strength as well as the effect of additives. Due to the benefits of measuring dough density as an indication of the proofing capacity of doughs, three methods for measuring dynamic density of wheat dough during proofing were investigated. A novel method which monitored the change in dough volume during actual proofing conditions (proofing cabinet, 35°C, 80% R.H.) with an imaging technique using structured lighting, was compared to two standard methods which included monitoring the change in weight of a dough piece in silicone oil at 35°C and monitoring the dough volume changes in the rheofermentometer at 35°C. Wheat doughs made from an Irish variety and a Canadian blend of varieties were studied. All the methods resulted in similar dough density profiles. However, dough density appeared to level off sooner when the oil displacement method was used, indicating that the sample was unable of withstanding longer proofing. However, the results from the other two methods and also from the gaseous release curve from the rheofermentometer showed that both samples were able to retain the CO_2 produced for at least 45 minutes and their expansion continued until that time. Dough density at the end of fermentation process was related to the loaf volume after baking and therefore evaluating wheat varieties (and potentially other cereals) by measuring dough density was proven to be a valid and accurate technique. The novel structured lighting method had the distinct advantage of taking place in actual proofing conditions as used in breadmaking and also it can be used to monitor dough density of batters (cake and confectionery, gluten free doughs) which is not possible with the other two methods.

P2P12

Vital wheat gluten characterization using Infraneo and Mixolab

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Vital wheat gluten is one of the most popular improvers in bakery industries. In spite of this industrial interest, instrumental methods to analyze physicochemical properties and rheological behaviour of this product are pretty rare. The objective of this study is double: to develop near-infrared calibrations on Infraneo (Chopin's NIR analyzer) in order to measure in few second proteins and moisture content, and to develop a Mixolab protocol that evaluates the rheological behaviour of different vital wheat gluten.

48 vital wheat gluten samples with moisture content between 2.8% and 7.3% and proteins between 70.9% and 82.3% were used for near-infrared calibration development. The obtained calibrations showed very good performances (R^2=0.95 and SECV=0.57 for proteins, R^2=0.96 and SECV=0.16 for moisture content).

6 vital wheat gluten samples, with different baking qualities, were used for rheological study. The developed protocol (200 rpm, 75 g of gluten, 120% of hydration) was strongly repeatable (difference between 2 repetitions was lower than 5%) and discriminated clearly the 6 tested samples.

Mixolab and Infraneo in combination provide a fast and complete scoring of vital wheat gluten samples.

P2P13

Hulless barley in processed meats and doughnuts: Who would have guessed?

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Whole grain barley is an excellent source of both insoluble and soluble dietary fibre. Despite its nutritional benefits and unique flavour, efforts to develop food products using barley and/or barley-based ingredients are lacking. Barley consumption is very low in the North American and European diets. In North America, barley is primarily used as animal feed (65%) and in the malting and brewing industries (30%) and only relatively small amount (1.5%) is utilised in the human food supply. Given its many nutritional benefits, its recent FDA health claim ruling in the U.S. and the rapidly growing interest in health and nutrition, barley should once again achieve a position in the diet not seen since the ancient world. Food products developed with barley and barley-based ingredients will meet this growing interest and fulfill some of our nutritional needs. Although the amount is small, food barley is available in a variety of formats including pearl and pot barley, white, whole grain and malted flour and barley that is rolled and flaked.

The purpose of this research was to study the effect of different types of whole grain hulless barley flour in processed meats and doughnuts. The barley varieties varied in βglucan and amylopectin content and were milled into whole grain barley flours. Processed meat products were formulated with these flours to enhance the water holding properties and reduce the fat content. The inclusion of whole grain barley flour into doughnuts was to increase the fibre content and to study its effect on dough quality, water and fat adsorption and shelf life. Instrumental and sensory evaluation were used to assess the impact of these additions. Particle size distribution of the flours was measured by laser diffraction spectrophotometry. In the last experiment, the products were prepared using composite barley flours that contained additional barley βglucan and product acceptability was examined.

P2P14

Effect of fat-replacement through rice milling by-products on rheological behaviour of dough

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Currently fat replacement is largely focused in products developments which are generally fat rich such as biscuits, cookies, cakes etc. Rice Bran and broken Rice are two major by-products of rice milling with important functional properties such as gelling, water absorption and emulsification. The known percentage of rice bran and rice endosperm

powder individually and in combinations was mixed with wheat flour to replace at least double of the quantity of fat. The Impact of substitution on rheological behaviour such as dough development time, dough strength, dough stability,peak viscosity, mixing tolerance index, geletinization temperature, water absorption etc were studied by farinograph, alveograph, mixograph, glutomatic, kernel and texture analyzer etc. A strong correlationship exists between functional properties of the nature of fat replacers and dough mixing performance/end quality, which is strongly linked to the particle size of rice products. It seems that the induced hardness due to reduction of fat may be eliminated by variation in certain parameters such as added water, mixing time, falling number (by including alpha-amylase), initial temperature etc. The results are promising and elaborate the competency of rice bran and broken rice as excellent economical and health stimulating future candidates for fat replacement in soft-dough biscuits.

Keywords: Rice milling by-products, Dough development behaviour, fat replacement, end quality impact

P2P15

Fermentation-induced changes on the structural and nutritional properties of bran

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Bran is a rich source of dietary fibre and phytochemicals, but posses only limited use in cereal products due to the deleterious effect of native bran on the quality of the final product. Fermentation of bran has been shown to improve technological functionality and level of phytochemicals of bran but throughout understanding of the state of fermented bran and significance of increased bioactivity has not yet accomplished.

In this study, influence of fermentation on the structure and properties of bran as well as bioactivity was established. Furthermore, fermented bran was introduced to the wheat bread (15–20% addition level), and textural characteristics and in vitro bioavailability (ferulic acid) of the subsequent high-fibre wheat bread were studied. Fermentation was performed either with *S.cerevisiae* or by using combination of yeast and enzymes (Veron CP, Depol 740L, Pentopan mono BG and Grindamyl Max life). Structural modification of bran was studied by establishing amount and MW of arabinoxylans (GC and HPLC), and by studying changes in cell wall structures of bran by light microscopy. Activity of endogenous xylanases (enzymatic method) and level of acidity was also measured from bran ferments. Bioactivity of fermented bran was studied by measuring amount of folates and phenolic acids by HPLC. Quality of subsequent breads was studied by determining specific volume (Bread Vol Scan) and instrumental texture (Texture Analyser). Bioavailability of free ferulic acid in wheat breads supplemented with fermented bran was studied in the TIM 1-model.

Tailored fermentation of bran increased amount of soluble arabinoxylans fivefold, modified MW of AX and lowered endogenous activity of xylanases. Significant degradation of cell wall structures were observed in micrographs of the fermented brans. These changes resulted in higher bread volume and softer bread texture in the subsequent breads. Tailored fermentation increased also level of folates nearly twofold and free ferulic acid (FA) 17-fold which also led to improved bioavailability of FA in the TIM 1-model. We conclude that bran fermentation is efficient mean to modify structure of the bran as well as level of folates and FA and results in the improved texture and bioavailability of FA of wheat bread supplemented with fermented bran.

Poster Session 3 • Thursday, March 26, 2009 16.00–16.45

P3P01

Structural investigations of arabinogalactan-proteins from wheat, rye and oat, isolated with Yariv reagent

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The non-starchy polysaccharides, although minor constituents in common wheat, rye and oat, are important for growth of plant tissue. Arabinogalactan-proteins (AGPs) from wheat induce embryogenesis in microspore culture [1] and play a role in breadmaking [2]. Already in 1975 [3], it has been claimed that in contrast to most other AGPs, those of oat and wheat show no precipitation with Yariv reagent. Therefore, up to now it is common praxis to isolate AGPs from cereals by stepwise ethanol precipitation. This includes the disadvantage of contamination of AGP-preparation with other polysaccharides.

Our investigations show for the first time, that AGPs from whole grain of wheat, rye and oat can be isolated as putative components with immunostimulating activities [4] by specific precipitation with ß-glucosyl Yariv reagent. With the results of methylation analysis with and without mild hydrolysis a structural model is proposed for the cereal AGPs: the carbohydrate moiety consists of a 1,3-Gal*p* backbone, linked in position 6 to short 1,6-Gal*p*-chains, terminating in Ara*f*. A high content of hydroxyproline is found, probably responsible for linkage between protein and polysaccharide moieties. Molecular weights of AGPs have been determined by GPC with LLS detection and found to be between 80 and 125 kDa. Hydrolysis of the protein resulted in carbohydrate moieties with a molecular weight of about 20 kDa.

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P3P02

Novel wheat bran and extracts with enhanced nutrient and bioactive properties

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A novel food-grade wheat bran, NovaBran™, has been recently developed at the University of Manitoba. It derives from a patented treatment process that enhances the extractability/solubility of many bioactive wheat bran constituents resulting in a product that is very different in sensory, rheological, and biochemical properties compared to traditional wheat bran. NovaBran lacks the strong and distinct sensory attributes of traditional bran, having a mild aroma and flavour that carries into bread. In whole wheat flour at 15% replacement level, it significantly improved farinograph dough strength and mixing tolerance compared to traditional bran; loaf volumes were unaffected. Most noteworthy are its chemical properties. In particular, antioxidant activities of soluble extracts are enhanced by more than 400% compared to extracts from unprocessed wheat bran. Arabinoxylan and βglucan solubilities which are very limited in traditional wheat bran were substantially increased in NovaBran. Cell and animal model studies undertaken to date have been equally compelling, with results reflecting a remarkable range of important bioactivities for both NovaBran and extracts. Using a hypercholesterolemic hamster model, NovaBran consumption compared to a control or traditional wheat bran diet was associated with increased metabolic rate, increased lean mass, lower fat mass and lower blood glucose. NovaBran extracts assessed in *in vitro* studies showed significant inhibition of cancer (hepatoma) cell

growth and significant increase in mouse macrophage cell proliferation suggesting immune enhancing properties. Results as a whole indicate that the nutritional and health benefits normally ascribed to traditional wheat bran likely represent a fraction of its potential. By enhancing the solubility of wheat bran and bioactive constituents, bioavailabilities are likely enhanced as well. NovaBran appears to have considerable value for whole grain food and health applications far beyond what may be possible with traditional wheat bran.

P3P03

Alkylresorcinol metabolites in human urine

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Alkylresorcinols (AR) have been suggested as biomarkers for intake of whole-grain rye and wheat. DHBA (3,5-dihydroxybenzoic acid) and DHPPA (3-(3,5-dihydroxyphenyl)-1-propanoic acid) are the two main alkylresorcinol metabolites. Alkylresorcinol metabolism is thought to consist of both phase I metabolism, including β- and βoxidation, and phase II metabolism leading to formation of conjugates. The aim of the present study was to assess the extent of conjugation of DHBA and DHPPA in human urine.

Urine samples from 10 individuals were treated without and with deconjugating enzymes (βglucuronidase, arylsulfatase and βglucuronidase with sulfatase activity) to evaluate the levels of free and conjugated metabolites. After extraction and solid-phase purification, free metabolites were quantified using GC-MS.

The measured concentrations of DHBA and DHPPA were 17-52 µmol/L and 11-79 µmol/L, respectively. DHBA was mostly found in the free form (67 ± 14%) and as glucuronide conjugates (18 ± 7%). DHPPA showed a different pattern, with smaller fraction in the free form (46 ± 14%) and larger fraction as glucuronide conjugates (39 ± 13%). Thus, DHBA and DHPPA are mainly present in the free form in human urine and their major conjugates are glucuronides.

P3P04

Impact of baking on the vitamin E content of the pseudocereals amaranth, quinoa and buckwheat

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Natural vitamin E is an important antioxidant in foods. It also has an important physiological role as a free radical scavenger protecting our bodies against degenerative diseases such as cancer and cardiovascular disease. It is composed of eight different compounds: four tocopherols (βT, βT, βT and βT) and four tocotrienols (βT3, βT3, βT3 and βT3). It is important to be able to quantify each vitamin E compound separately as they all have shown different antioxidant and biological activities. The pseudocereals amaranth, quinoa and buckwheat have an excellent nutrient profile; they are high in good quality protein, fibre and minerals and are rich in polyunsaturated fats and vitamin E. Also they are gluten-free and can therefore be used as healthy ingredients in gluten-free products such as breads. However, little is known about the impact of high temperature processing such as baking on the tocol content of these pseudocereals. In the present study, a rapid normal phase HPLC method was used to determine tocopherols and tocotrienols in the pseudocereal seeds and to study the effect of baking on vitamin E recovery. The pseudocereal breads were produced following a standard gluten-free formulation based on rice flour, and two levels of replacement of rice were studied, 50% (amaranth, quinoa and buckwheat) and 100% (quinoa and buckwheat). In the seeds, total tocol content was highest in quinoa (72.5 ug/g dwb), followed by buckwheat (50.0 ug/g dwb) and amaranth (35.0 ug/g dwb) and was significantly higher for all pseudocereal seeds ($p<0.01$) compared with wheat (17.6 ug/g dwb). No tocotrienols were found in the pseudocereal seeds and tocopherol composition varied between seeds. Measured tocols levels in breads were high which suggests that vitamin E survives the breadmaking process. As expected, total tocol content was highest for 100% quinoa and 100% buckwheat breads (74.3 and 65.5 ug/g dwb).

P3P05

Content of some phytochemicals in barley, oat, rye and wheat cultivars

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Cereals, such as barley, oats, rye and wheat, contains selection of very interesting minor components, which could have a vital role in the plant's defence system against biotic and abiotic stress. As cereals are used for food, the same compounds as ingested can have health promoting properties. Many of these compounds have been found to have antioxidative or anticarcinogenic activities or have some other specific physiological activity.

The contents of some selected phytochemicals, namely alk(en) ylresorcinols in barley, rye and wheat, benzoxazinoids (DIBOA and DIMBOA and their conjugates) in rye and wheat, catechins and hordatines in barley, avenanthramides and bisdesmosidic steroid saponins in oats, were analyzed by HPLC-DAD. In the study, four cultivars of each cereal were included except in wheat, which had only three cultivars.

In alk(en)ylresorcinols the ratio of maximum to minimum value was in rye 2.1, in wheat 1.5 and in barley 2.0. In rye the max-min –ratio of benzoxazinoids was 4.3 and in wheat 2.5.

In barley cultivars the max-min –ratio of total catechins was 2.6 and hordatines 2.2.

In oat cultivars the max-min –ratio of avenanthramides consisting of anthranilic acid conjugates and of avenanthramides consisting of avenalumic acid conjugates was 2.0 and 2.9 respectively. For avenacoside saponins in oats the ratio was 2.0.

According to the results, there is a great variation in the contents of phytochemicals between various cereal cultivars. However, to have more evidence concerning the cultivar-related differences, more harvest years should be included in the study.

P3P06

Phytosterols and steryl ferulates in dry milling fractions of wheat

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Cereals are an important source of natural phytosterols and their conjugates. Even higher phytosterol content and intake could be achieved by introducing the most phytosterol rich parts of the kernel into foods. To study the distribution of phytosterols and steryl ferulates in the wheat kernel, the contents of these bioactive compounds in 10 dry milling fractions of wheat were determined. The samples were produced in the HEALTHGRAIN project and included aleurone samples and fractions obtained after peeling or pearling processes [see Hemery et al., 2008, J. Cereal Sci. (in press)]. The analysis of phytosterols was performed using GC-FID, and the steryl ferulates (campesteryl ferulate, sitostanyl ferulate and the sum of campestanyl and sitosteryl ferulates) were analysed using RP-HPLC with UV detection.

The highest total sterol contents were found in the aleurone samples and a pearling fraction, and considerably high contents were also measured in the bran fractions. The highest contents of steryl ferulates were found in the bran after peeling and the pearling fraction. Notably high contents of steryl ferulates were also found in the aleurone samples. Both phytosterols and steryl ferulates were thus heavily concentrated in the

outer kernel layers, and the 76% flour from peeling or pearling contained only 16–17% of phytosterols and 2–3% of steryl ferulates compared to the richest fractions. Interestingly, the pearling fraction contained over 60% more phytosterols and over 300% more steryl ferulates than the peeling fraction, indicating that the most phytosterol and steryl ferulate rich layer was under the layer that was peeled off.

These results suggest that phytosterols and their ferulate esters are not evenly distributed in the kernel; instead their levels are higher in the outer layers. Furthermore, these bioactive compounds may have differences in their localization in the outer layers of the kernel.

P3P07

The impact of seed coat on bile acid binding capacity of broad bean, chickpea, green lentil, and red kidney bean

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Seed coat and coatless seed flours from broad bean, chickpea, green lentil, and red kidney bean were examined for their bile acid (BA) binding capacities. Flours were digested by an *in vitro* system that simulated human digestion, using alpha-amylase (from human saliva), porcine pepsin and pancreatin enzymes. All the seed coats bound greater BA than did the coatless seeds. BA binding capacities of broad bean, green lentil, and red kidney bean seed coat were almost 2-3 times higher than the positive standard, cholestyramine. Extraction of the seed coat flours, using consecutive methanolic (methanol:water, 50:50 v/v) and acetonic (acetone:water, 70:30 v/v) solutions to obtain antioxidant-free seed coat flours, did not change the BA binding capacity of broad bean and chickpea seed coats but significantly decreased BA binding capacity of red kidney bean and green lentil seed coats. Lignin content was the only component that significantly correlated with the BA binding capacities of the samples.

P3P08

Comparison of antioxidants content in seeds and their sprouts by amperometric method

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Cereals and cereals products (bread and bakeries) are important sources of antioxidants in a human daily ration. The big interest is involved with the sprouted grains.

The purpose of our report is comparison of the antioxidants content in dry seeds of cereals cultures and their sprouts. The total antioxidants content in initial dry seeds and their sprouts on the second and fifth days after the beginning of sprouting has been defined by amperometric method on the device "TswettYauza-01-β". Results are presented in the below table.

The total antioxidants content (TAC) in dry seeds and sprouts of different cultures in recalculation on absolutely dry weight (mg/100g) (the standard -quercetin)

Culture	The total antioxidants content (mg/100 g)			The ratio of TAC: five days sprouts to dry seeds
	Dry seeds	Two days sprouts	Five days sprouts	
Wheat	24	69	275	11.5
Rye	29	102	320	11.0
Oats	34	65	334	9.8
Buckwheat	182	203	383	2.1
Lentil	42	72	90	2.1
Garbanzo bean	84	190	503	5.9
Mash bean	102	263	517	5.1
Sesame black	291	150	490	1.7
Pumpkin	33	65	333	10.1
Flax	56	201	526	9.4
Amaranth	0	17	200	20
Milk Thistle	235	334	896	3.8

The table shows that the total antioxidants content increases from 2 to 20 for all sprouted seeds. The most antioxidants content is present in dry seeds of buckwheat, [illegible] black and thistles spotted. Unusual results are received for amaranth – TAC increased in 20 times for the sprouted grains. The increasing of the antioxidants content of seeds at sprouting is genetically established to protect sprouts in the first days of their life from influence of unfavorable environmental factors. We had been defined also the antioxidants content in the food products made from seeds of different grain crops and buckwheat. In flour and groats the content of antioxidants is fluctuated within 20-60 mg/100g. In this study has been found that any processing of grains reduce their antioxidants content. From groats (grains) the minimum amount of antioxidants contains semolina, and the maximum – fine-ground barley and buckwheat. The content of antioxidants in polished rice is 5 times less than in non-polished.

This research are performed within the limits of work on Data bank building under the content of antioxidants in food, food ingredients, functional beverages and dietary supplements. Sprouted seeds—a good source of antioxidants—can be used for achievement of recommended daily value of total antioxidants consumption—not less than 360 mg. The regular usage of the sprouted seeds is a necessary element of a healthy mode of life.

P3P09

Applying analytical hierarchy process to select the best whole wheat flour with or without hydrothermaled bran

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Making a decision to improve bread quality and produce more properly nutritional product is usually followed by selection of the best wheat flour to be applied in baking process. This selection is influenced by different factors such as rheological properties and chemical composition of wheat flour. Whole wheat flour is popular for producing Iranian flat bread especially in villages. Whole wheat flour bread is getting more popular nowadays due to more fibrous and nutritious values. The aim of this study was to propose analysis based on the well-known analytical hierarchy process (AHP) multi-criteria decision method and led to the definition of a general decision hierarchy. The resulting flour and dough containing hydrothermaled bran showed a better physicochemical and rheological properties than those made with normal bran in both of wheat varieties (Tajan and Back Cross of Roshan). The decision hierarchy and the results obtained were validated by a panel of experts and are thus suitable for use as a tool for bakery industry experts.

Key Words: Whole wheat flour; AHP; Phytate; Hydrothermaled Bran.

P3P10

Non-targeted metabolite profiling of rye bran metabolome processed by human microbiota *in vitro*

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Metabolomics is currently one of the most rapidly expanding analytical approaches applied to multiple research areas, including human nutrition. In our research group non-targeted metabolite profiling by UPLC-qTOF-MS is applied for microbiota-treated rye bran. The analyzed sample set contains water-soluble and non-soluble fractions of rye bran incubated in an *in vitro* colon model. In this model the rye bran fractions are fermented by human faecal microbiota, and samples are collected at 2, 12, 24 and 48 hour time points. It is widely known that the metabolism of the microbiota modifies the food-born compounds and thus alters their bioactivity, e.g. the formation of enterolactone and enterodiol from lignan precursors in whole grain rye. These components are believed to add to the health related impact of plant derived food like whole grain products, and thus it is of major interest to try to eluicidate the metabolic process occurring in the colon between the microbes and the food components. The current LC-MS technologies applied in the field of metabolomics allow detection of sample constituents with extremely high separation efficiency and accurate mass detection. Such approach is applied in this study in order to monitor the change in the rye bran soluble and non-soluble metabolite fraction as time course in the fermentation process. We aim to detect the proportional changes occurring in the metabolites and to identify the newly emerging compounds after the microbial treatment. *This work is part of the Nordic Centre of Excellence program in the area of nutrition, food and health, within the projects HELGA-Whole Grains and Health and SYSDIET- Systems biology in controlled dietary interventions and cohort studies.*

P3P11

The ingredient wheat aleurone the most valuable fraction from the outer layer of the wheat

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The wheat aleurone ingredient respectively the wheat aleurone layer is the most promising fractions from the outer layer of the grain with its unique benefits as it is also described within the European HealthGrain project. The importance of scientific work and their importance for successful break through innovations will be described with relevance for the consumer market message.

This process breakthrough enables recovery of the valuable aleurone cells from wheat bran to yield a light coloured, free-flowing powder wheat aleurone ingredient that can be used to enrich a host of food applications without sacrificing taste and texture. The innovative technological steps and a detailed product characterization with their main compounds as well as an overview about the scientific studies will be shown together with some innovative product concepts.

The pure wheat aleurone cells with its valuable dietary fibre mainly the arabinoxylans from the aleurone cell wall with a high content of antioxidants and other micronutrients shows within pre-clinical and clinical studies the protective benefits for intestinal health. Furthermore there is some evidence, that the wheat aleurone ingredient has a positive effect on blood pressure and reduces the natrium absorption. Wheat aleurone which was proven to reduce the risk of hypertension and diabetes is expected to contribute to the prevention of hyperlipidemia and obesity as well if continued over a longer period.

Biscuits, Pizza, chocolate but also dairy based cereal drinks are some very promising new application concepts for health aware consumers with this unique ingredient.

Key Words: innovative technology, wheat aleurone, intestinal health, blood pressure, application concepts

P3P12

Waxy winter barley—high-yielding and rich in beta-glucans

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Whole grain cereal foods are known to have positive effects on lipid metabolism and to reduce the risk of cardiovascular disease. While wheat is currently the primary stable food for almost one-third of the world's population, the consumption of other small grain cereals is low. This is especially true for barley, which is popular for human consumption only in North Africa, the Near East and parts of East Asia. Despite reports that barley has a significant cholesterol-lowering effect in humans it is used almost exclusively as animal feed and for brewing purposes in Western countries.

The positive effects of barley consumption on blood cholesterol are attributed to its high content in soluble beta-glucan. Because of the altered carbohydrate metabolism in barley comprising the waxy gene, these barley genotypes have comparably high beta-glucan contents. In 2008 Dieckmann Seeds was the first breeding company to have a waxy winter barley variety listed in the Common Catalogue of Varieties of Agricultural Plant Species called 'Waxyma'. This conventionally bred variety combines high beta-glucan content with the advantages of a winter barley, is high yielding and has a good resistance against lodging and fungal diseases. 'Waxyma' contains about 6% of beta-glucans. This is 50% more than conventional barley contains and still considerably more than oat contains. At the same time the starch of waxy barley consists of about 95% of amylopectin leading to a good solubility and a gelatinization at a much lower temperature than for native wheat starches. Milling of 'Waxyma' grains yields a good amount of white flour, which is particularly mild in taste. Despite its light colour the flour contains about 1.5 to 2% of mineral compounds. The water binding capacity is twice as high as for wheat flour.

Due to its positive rheological and sensorial properties flour made of waxy barley can be utilized for the production of various types of food. This might be of interest on the background of an FDA Health Claim and an EU Health Claim proposal both concluding that barley consumption contributes to the reduction of blood cholesterol. This might lead to a revival of a crop that used to have a good share in the human diet for more than 7000 years.

Poster Session 4 • Thursday, March 26, 2009 16.45–17.30

P4P01

Potential of wheat bran dry fractionation for the production of food ingredients

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The current wheat milling process aims at recovering white flour only. Wheat bran is thus a by-product used for animal feeding, even if due to its high nutritional potential, it could be used as food ingredients to increase the quality of human foods. Dry fractionation processes aim at making better use bran, and recovering separately the different bran layers, to produce fractions rich in different tissues, like pericarp-rich fractions (rich in fibers) or aleurone-rich fractions (rich in vitamins, minerals, antioxidants). This poster describes the different steps of wheat bran fractionation, from the

characterization of the starting material to the evaluation of the different bran fractions obtained. The potential of two processes was studied: ultra-fine grinding and electrostatic separation. First, the mechanical properties of the different bran layers were studied, to define the conditions in which these bran layers were the most brittle. Grinding tests were then carried out at small scale, to evaluate the effect of low temperatures on particles size reduction. As very fine particles where obtained, ultra-fine grinding was tested at pilot scale to compare cryogenic and ambient grindings, and to produce ultra-fine bran with a median particles diameter inferior to 50µm. In these ultra-fine fractions, most of the bran layers and cellular structures were dissociated. In a second time, the sorting of bran particles was studied, using electrostatic separation. Therefore, electrostatic properties (ability of particles to get charged by triboelectrification and to keep an acquired charge) were studied for whole bran and for pericarp-rich and aleurone-rich fractions. As these different types of particles were found to exhibit contrasted properties, the electrostatic separation of ultra-fine bran was carried out at pilot scale, and allowed to obtain fractions that exhibited different biochemical compositions and contained different bran tissues proportions. The different fractions obtained by these processes were then tested for their techno-functional properties: their impact on dough properties and bread quality was studied while they were used to prepare pseudo whole breads. These breads then underwent an *in vitro* digestion, so the influence of the bran fractions on the bioaccessibility of bioactive compounds was measured. This study showed that bran and bran fractions have a good potential as food ingredients.

P4P02

Sensory consumer tests and instrumental evaluation of healthier oat breads

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Currently there is an increasing interest on the development and consumption of fibre-enriched cereal foods. Despite of the growing interest in the health aspects of whole grain products, good sensory properties remain a key priority as a consumer choice criterion.

Oat flour is characterised by high fat and high quality protein contents. Moreover, oat fibre contains significant amounts of soluble beta-glucans related to cholesterol lowering function (Heiniö, 2003). Whole grain oat can be used to improve the taste of bread, and imparts a pleasant nutty flavour (Salmenkallio-Marttila et al, 2003) having a great influence on flavour properties and flavour stability of oat breads.

In this work, two wheat flours have been supplemented with oat flours at different substitution rates (20% and 40%) resulting on four different bread samples. Wheat flours with high and very high protein content have been chosen, in order to compensate for the negative effects of whole grain oat flour on gluten development.

Rheological properties of sample flour blends, physical evaluation of breads, after baking and during staling have been performed. 93 consumers rated the four breads according to a 9 point hedonic scale in order to find out if there were differences on the hedonic evaluation of the four breads. Results show no significant differences among the four breads (control pan wheat bread and the three barley flour supplemented breads) in crumb firmness and elasticity evaluated 24 hours after baking. Nevertheless, from the staling point of view, evaluated on the basis of the evolution of the decrease on elasticity over 3 days, sample with the higher protein content and 40% oat flour showed the best behaviour.

No significant differences were found on the hedonic ratings of the four breads.

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P4P03

Use of hull-less oats in extruded products

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Consumers pay more attention to selection of healthy and balanced diet nowadays. Bread products often are replaced with wholegrain products, extruded products, crisp-bread. Extruded products are typically made from wheat, rye, rice and buckwheat flour, although there is a possibility to use oat especially hull-less oat flour.

The origin of hull-less oats can be found already in the 5th century in China. Nevertheless this type of oats is a new crop for Latvian agriculture. Hull-less oat is covered with thin layer, which is separated during harvesting.

Oat is a product of high energy and biological value, which has significant role in human nutrition. Hull-less oat has slightly different chemical composition when compared to hulled oat. The study on Latvian hull-less oat chemical composition proved it contains by 21.3% higher content of lysine, 5.76% - isoleucine and 5.4% - treonine. Content of vitamin E and βglucan is by 46% and 2% higher, respectively.

Improved biological value was the reason for use of hull-less oats in production of extruded products, replacing 50% of wheat flour with hull-less oat flour.

As a result, the new product contains higher amount of fibre, especially βglucan, by 1.21 mg 100 g^{-1}, content of vitamin E – up to ~3.0 mg 100 g^{-1}, which is about 2.5 times higher than its content in wheat crisp-bread. The analysis of fats demonstrated that hull-less oat crisp-bread contains 6.565% total fat, oat crisp-bread - 4.87% total fat, while wheat crisp-bread - 1.99% total fat.

P4P04

Breakfast cereals from whole grain, bran and fibres—challenges and risks

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One of the most important processes for making breakfast cereals is extrusion.

Gelatination as well as cooking-extrusion are used.

To follow the recommendations of nutritionists and market trends the content of sugar and fat should be reduced, the content of fibres should be increased.

The use of whole grain, bran and or isolated fibre products can help to achieve these aims.

The author reports about technological, sensory and analytical effects from trials by gelatination and cooking-extrusion to produce breakfast cereals.

Relating to the increase of whole grain components, addition of bran (coarse or fine grinded) the resulting effects (expansion index, sensory, bulk density, resistance in milk, colour index, taste) were registered.

Strategies and results to increase consumer relevant properties and to decrease the generation of acryl amide are described.

P4P05

Enhancing beta glucan levels of wheat breads by the inclusion of milled barley fractions

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The health related importance of soluble fibres such as βglucan has long been recognised: it has been shown that βglucan has a positive effect on glycaemic insulin and cholesterol responses and also acts as a prebiotic. Due to its high soluble fibre content, nutritional significance and plentiful supply in Ireland, barley is a desirable food/ingredient for functional foods.

Following preliminary beta glucan analysis, doughs were produced using barley endosperm flour or barley ends/pollard, in different ratios with wheat flour. A 100% wheat flour formulation was used as a control. Dough rheological properties were evaluated using fundamental oscillatory tests and extensional tests using a Kieffer Extenisibility Rig. Amplitude sweeps were carried out to evaluate the linear visco-elastic region (LVER) of each of the doughs. The resulting LVER characteristics were used to produce the conditions necessary to carry out frequency sweep tests. The baked breads were evaluated for volume, texture, moisture, dietary fibre and beta glucan. Digital image analysis of the crumb grain was also carried out.

Frequency sweeps of the doughs revealed that an increase in barley fractions lead to the doughs having a higher complex modulus (|G*|, i.e. firmer) with the increase in barley fraction making |G*| more dependent on frequency. Extensional rheology revealed that increasing the levels of barley fractions in the doughs lead to the doughs rupturing at lower extensions. Lower levels of barley flour (<50%) and ends (<30%) did not significantly effect loaf volume or crumb texture. However, above these levels, volume decreased ($P<0.05$) and the rate of starch retrogradation (i.e. staling) increased ($P<0.05$). Also, the area of the holes (mm^2) and number of holes within the crumb grain became unacceptable at these higher levels. Total dietary fibre and beta glucan levels were significantly increased with the inclusion of the ends fraction of the barley. Optimisation of a bread formulation containing the pollards fraction is now planned, using Response Surface Methodology.

P4P06

Quality of baked products made with whole grain hulless barley

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Interest in using whole grain barley flour as a partial replacement for wheat flour has increased because of the reported health benefits associated with barley. Barley is a good source of soluble fibre (βglucan) and insoluble fibre and has high concentrations of tocotrienols, tocopherols, phenolic acids and lignans. Research has shown that barley βglucans can lower blood cholesterol levels. Based on this evidence, a heart-health claim is permitted in the United States for foods containing barley. This study was undertaken to evaluate the quality of pan breads, bagels and tortillas made using whole grain barley flour. Hulless barley varieties varying in amylose content registered and grown in Canada were milled into whole grain flours using a pilot-scale Buhler mill. Modifications to the formulation and processing conditions were required for all products containing barley flour compared to the wheat flour control due to the compositional differences associated with barley compared to wheat. Both the level of replacement and the barley variety used affected end-product quality. For all baked products, it was possible to achieve high quality end-products using relatively high levels of whole grain barley flour and in most cases these levels met the βglucan level required for a health claim.

P4P07

Use of whole grain flours in the production of pasta

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Changes to the recommended daily intake of dietary fibre in both Canada and the United States have resulted in the need for foods with enhanced dietary fibre to help consumers meet their daily requirements. Addition of whole grain barley flour and whole grain pulse flours offer interesting alternatives to traditional fibre sources. Whole grain barley flour is a good source of soluble fibre (βglucan) and insoluble fibre and whole grain pulse flours made from beans, lentils and chickpeas contain high levels of insoluble fibre. The objective of this study was to evaluate the processing characteristics and quality of pasta made by partially substituting durum semolina with whole grain barley and pulse (chickpea, bean and lentil) flours. Spaghetti was processed from durum semolina and several levels of whole grain flours using a pilot-scale pasta press. Spaghetti was then dried using commercial conditions. Cooking quality of the dried spaghetti was determined using both instrumental and sensory methods. For all flours tested, there was a level of substitution where color, flavor and texture were optimal. The results showed that it was possible to significantly increase the level of dietary fibre in the spaghetti through the addition of whole grain barley and pulse flours and these products were commercially acceptable in terms of processing characteristics and end-product quality.

P4P08

Microbial and enzymatic modification of wheat bran properties at reduced water content

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Cereal bran is high in dietary fibre and a good source of health promoting compounds. Enzymatic or microbiological methods offer means to improve the technological properties of bran. Water content is an important parameter in such modifications, influencing f.ex. the diffusion of components and rheological properties of the material. In studies concerning enzymatic or microbial modification of bran, the reactions have often been conducted at high water content. In industrial scale applications, low water content may be advantageous, especially in processes followed by drying as a post-treatment procedure.

The aim was to study the effects of water content ranging from about 30–90%, on yeast fermentation and xylanase treatment of peeled wheat bran. Yeast was metabolically active also at low water activity, as shown by carbon dioxide production. Folate content and the amount of free ferulic acid approximately doubled in yeast fermentations at high water content, but did not markedly change in yeast fermentations at low water content. Instead, the amount of soluble arabinoxylan increased significantly also at low water content. In the enzymatic xylanase treatments, arabinoxylan solubilization was highest at the water content of about 40%, where material was transformed from powder like material into a plastic mass. The effects of water content on the kinetics of xylanase action are being further studied.

P4P09

Characterization of typical traditional whole-grain breads made in Sicily (Italy)

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The new guidelines suggest whole grain intake as rich source of fibre components useful in health safeguarding. Over 50 different kinds of durum wheat bread are produced in Sicily, Island situated in the Southern of Italy. Traditional processes are still used, with durum wheat flour as the main raw material. In order to safeguard and to add value to typical high quality products, this study aimed to examine three kinds of whole grain bread produced in the Island. *Pane nero di Castelvetrano* (from Trapani) and *Pane di Lentini* (from Ragusa) are still traditionally produced by smaller bakeries using an old autochthonous population of durum wheat, *Timilia*, traditional millstones, and natural yeasts; the *Pane intero del Dittaino* (from Enna) is an industrial product that safeguards the traditional bread-making conditions by using natural yeasts.

The chemical characterization of the three kinds of bread showed significant differences. As matter of fact, on average, protein content ranged from 11.2–13.6% d.m. and lipid concentration from 2.1–3.9% d.m.; total starch content showed minus marked differences, the range of variability being 61.8–62.3% d.m. Significant differences also occurred among the considered breads in total dietary fibre (TDF) content, whereas similar across breads was the Resistant Starch content (about 1% d.m.), the indigestible starch fraction known for potential health benefits in the human colon. No marked differences were evidenced in the chemical composition of different bread parts (crust and crumb).

The results of this study could allow to promote consumption of Sicily high-fibre breads and to identify the best value –adding opportunities for bread producers.

P4P10

Examination of nutritional properties of breads made by triticale and winter wheat flour mixtures

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Triticale (*Triticosecale Wittm.*) is a hybrid and successfully combines the favourable properties of wheat and rye. Besides it has less demands during the field production as wheat, it has much better nutrient and water utilization, that became more and more important nowadays, when the precipitation in the vegetation period is increasingly less and unpredictable. It has much better resistance to biotic stresses, what decreases the occurrence of fungus toxics and gives significant advances in bio production. Moreover, the highest antipathy to flour and bread consumption nowadays is follows from the high level of easy digestible carbohydrates, low level of dietary fibre and minerals of recently consumed white bread. Beside triticale contains significantly more dietary fibre as wheat flour, it also has more advantageous amino acid composition, especially because of its high methionine, cysteine and lysine content. While the traditional cereals as wheat, rye and corn face up to the harms of slow increase in yield and relative high level of environmental pollution (because of the intensive agronomy caused high mineral fertilizer and pesticide utilization), triticale could be a healthy alternative.

In our study we have examined the properties of a Hungarian listed triticale variety, bred specially to bread making. Although it is suitable for bread making itself, economic considerations requires its blending to wheat flours. To create a recommendation for the blending considering both nutritional and economic aspects, we made trials to examine the effect of milling rate (from the traditional to the whole grain) and the winter wheat flour addition on the physical (test loaf volume, sensory properties and crumb and crust structure) and nutritional properties (protein, amino acid, dietary fibre and energy content) of test loafs. The presentation summarizes our main analytical results.

P4P11

Effects of particle size of nutritional parameters of wheat flours

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Wheat is one of the most important cereals in the world and the bread made of its flour belongs to the everyday life of human mankind.

We use different methods and systems to determine the quality of crops' products like wheat, because we cannot identify the quality of grains with one single parameter only, since there is nothing, like 'absolute quality'(GYβRI-GYβRINÉ, 1998).

The Hungarian standard relating to the laboratory production of wheat flour (MSZ 6367/9-1989) does not mention the type of laboratory mill used for milling, and it only builds up some general criteria, such as: the laboratory mill should be provided with four differently nicked barrels, a sieve with appropriate hole sizes, and also with the separated collections of the pilot flour and the bran. Our study was started at this point and the answers for the following questions were aimed to be found: do the flour patterns studied and produced with different grinding and sieving techniques, widely used in laboratory mills of the same wheat pattern show any alterations after the impact of the formula production as regards chemical constitutions and reologic parameters. Various flours and whole grains of the wheat patterns sieved with different particle sizes were studied in this experiment.

In producing this pattern two different mill types of FQC 109 and CHOPIN CD 1 as well as two different grinder types such as PERTEN 3100 and type of RETSCH 200 were applied.

There were 3 different corn sizes of 160; 250; 800 μms used in the partition of the fractions.

To study the differences the following measurements were conducted: dry matter, ash, protein content, wet gluten content, gluten index, gluten expansiveness, farinographic value, falling number and amilographic rate.

The results this research confirm that the quality of wheat flour can be modified by different methods of pattern production. In all cases the differences can be explained by the flour-bran ratio, and in some of the cases the higher germ content of the fractions also played a role. The results show differences between the various types of mills and grinders, too.

P4P12

The technologies of grain processing by extrusion in Ukraine

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Every year Ukraine has a huge grain harvest, from 30 to 52 million tons. Old grain storage facilities and modern steel installations are used for the grain storage. There is a lack of them in agricultural sector.

For this purpose new technologies providing complex processing of different grain material into feed and food products, their distribution in cattle – breeding, poultry and trade food stores are developed and installed.

The complex processing such cultures as: winter wheat (Triticum vulgare), oat (Avena sativa), buckwheat (Fagopyzum esculentum Moench), peas (Pisum sativum), millet (Panicum miliaceum), soybean (Glucine hispida), spring barley (Hordeum sativum jessen) is the result

of high pressure from 8 to 27 MPa and temperature during by extrusion at special one and two-worm extruders by Ukrainian production.

From different grain blends (5^{th}-6^{th} quality level) extruded fodders with high level of assimilation (palatability) by animals and long terms of storage are produced.

From edible grades of grain boil soft products, food concentrates, semi-finished cereals, etc. are produced that provides effective grain usage. Elaboration of scientific basis of technological processes and perfection of technological conditions for achieving a high quality processed product are the subjects of the research in this sphere.

On the basis of the development of the experimental model of extruders at the "Elevatormash" Cherkaskii plant the number of standard size extruders with the output from 250kg/hr to 1500kg/hr working on grain raw materials of both separate cultures and blends are produced.

During the research and testing the characteristic of optimal grain compression, its temperature, and the condition of plastic fluid grain mass under its transformation in the working area as well as the character of its liquidity through the exhaust filter are determined. The research data allows improving the working organs constructions and technological process.

P4P13

Effect of phospholipase usage on volatile content of bread

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Certain phospholipases have started to be used for quality improvement of baked products in bread-making industry in view of the emulsification properties improving of lecithins. By sensorial analyse of bread loaves there was observed a light improvement of their flavour and taste in relationship with phospholipase usage, too. Alcohols, carbonyl compounds, acids, esters, lactones etc. are mainly volatile compounds of fresh bread that are responsible for its flavour, and they are formed in different stages of bread-making, by partially degradation of lipids for example.

The aim of that study was quantification of some volatile compounds from bread loaves, by using recipes with addition of different doses of a commercial available phospholipase, named Belpan FTG. The working methodology consists of two steps: firstly, it was performed baking tests, by using different doses of Belpan FTG like improver, and secondly the volatile compounds determination was achieved through steaming extraction and analysis by GC-MS. Their identification was made by comparison of mass spectra according with NIST database, and volatile content was assessed on the basis of a calibration plot.

Through experiments, seven alcohols, eight aldehydes, five esters, a lactone, ether and a pyrazine were investigated. Like alcohols, 1-pentanol, 2-methylbutanol, 4-pentanol, 1-hexanol, 1-hepten-3-ol, phenyl ethanol and 1-octanol were determined. Hexanal, pentanal, heptanal, 2-heptenal, benzaldehyde, 2-octanal, nanonal, and (*E,E*)-2,4-decadienal were identified from aldehydes compounds. Five esters of fatty acids, namely ethyl myristate, ethyl palmitate, ethyl linoleat, ethyl oleate and ethyl stearate, were achieved. 3,6-dimethyl-hexa-benzofuran, 5-hidroxy-methyl-dihidrofuran-2-one and 2-ethyl-6-methyl-pyrazine were assessed, too.

GC-MS analysis of volatile content of improved breads has showed a mixture of 35% alcohols, 42% aldehydes, 20% esters, as for the rest lactones, pyrazines and ethers. By using Belpan FTG as baking improver, bread loaves acquired an increasing trend for concentration of volatile compounds such as alcohols, and aldehydes, esters, pyrazine and ether in respect of augmentation of enzyme dosage.

P4P14

Variations in arabinoxylan structure in the endosperm cell walls of cereals from the HEALTHGRAIN diversity screen, determined using FT-IR spectroscopy and ^{1}H NMR

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For the HEALTHGRAIN diversity screen, 151 bread wheat lines and 50 other lines of small grain cereals (spelt, durum wheat, *T. monococcum*, *T. dicoccum*, oats, rye and barley) were selected for differences in their geographical origin, lineage and agronomic/quality characteristics. They were grown on a single site in Hungary in 2004/05, harvested, milled and analyzed to determine the extent of variation of bioactive compounds which are considered to have health benefits. Arabinoxylan (AX) is the major dietary fibre constituent of most cereal cell walls, and so was examined further for variation in composition, chemical structure and spatial distribution within the grain.

50 varieties of wheat and 2 for each of the other members of the Triticeae were selected according to variations in the soluble/insoluble AX content. Cell-wall-only thin sections were produced for each variety, and the spatial distribution of lower-branched and higher-branched AX was determined across the endosperm cell-wall network using FT-IR spectroscopic mapping. Varieties were identified that consisted of entirely lower-branched AX (e.g. cv Claire), entirely higher-branched AX (e.g. cv Manital) and a mixture of the two (e.g. cv Hereward).

Six varieties of wheat (showing major differences in AX composition) and one for each other cereal were selected for further FT-IR analysis. These were also analysed using a recently devised ^{1}H NMR spectroscopic method, which has allowed the proportions of mono-, di- and un-substituted xylose to be determined for the first time.

In vitro digestion tests have been carried out for varieties showing major differences in AX composition to characterise how the different cell wall types may respond to the environment in the gastrointestinal tract. Such changes may be relevant to understanding differences in beneficial health characteristics of these different wheat lines.

P4P15

Fibres and taste: Effect on crispness

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Wholegrain and high fiber have become clear trends in the food market. Products with a high (> 3%) content of fiber are considered an essential part of a healthy diet. With the appropriate measures quality losses can be minimized, but what about the stability of quality? This specially holds for freshly baked products, that are liked because of their crispy crust. In this study we investigated to what extent crispiness and crispiness retention are affected by fiber.

Previously, we have demonstrated that a certain type of cellular structure [1] clearly affects the crispness of a fresh cellular solid crispy food. Crispness and its retention were studied using a combination of acoustical/mechanical techniques and sensory analysis. We used this methodology to systematically analyze the effects of fiber addition on crispiness behaviour and retention. Studies were carried out using toasted rusk roll prepared from flour or whole meal. The whole meal product 'Volkoren Beschuit Bolletje' (Bolletje B.V., Almelo, The Netherlands) contains 7.5% of fiber [2]. The flour product 'Echte Beschuit Bolletje' was produced by the same company.

Fresh samples had an a_w=0.3. These were characterized by fracturing a standardized specimen at 0.4 mm/s. The effect of water uptake was studied by equilibrating rusks at various humidity conditions varying from RH 30%, until RH 80%.

Fiber toasted rusk roll did not show significant crispness differences with respect to the standard commercial product and at $0.3 \leq a_w \leq 0.8$. We also prepared fiber as samples for water sorption studies. No increase in sorption kinetics was observed. Moreover, there was no significant difference between the water sorption isotherms between the product without or with fibers.

(1) Castro-Prada, E. M., Meinders, M. B. J., Primo-Martín, C., Hamer, R. J. , Vliet, T. van. 2008. Relationship between cellular size, fracture, acoustics, and crispness perception. To be submitted.

(2) www.bolletje.nl/producten/cat/ontbijt_lunch

Parallel Session 3 • Friday, March 27, 2009 09.00–12.30

Phytochemicals, Processing, and Analysis

Chairs: Rui Hai Liu, Cornell University, U.S.A.; Jan de Vries, CSM, the Netherlands; Michela Petronio, Barilla, Italy

S301 09.00–09.30

Cereal dietary fibre as natural functional ingredient to deliver phenolic compounds into the gut

Vincenzo Fogliano, Aurora Napolitano, Paola Vitaglione

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Cereals such as wheat, barley, oat, rye, and maize, are staple foods for the population of Western countries contributing about 50% of dietary fibre (DF) intake. This paper focuses on the antioxidant component of cereal dietary fibre starting from its chemical structure, bioavailability and biological meaning.

The conversion of the highly polymerized insoluble dietary fibre into soluble feruloyl-oligosaccharides of DWF was achieved by a tailored enzymatic treatment. The *in vitro* fermentation and release of ferulic acid by intestinal microbiota from DWF before and after the enzymatic treatment were assessed using a gut model validated to mimic the human colonic microbial environment. Results demonstrated that, compared to DWF, the enzyme-treated DWF (ET-DWF) stimulated the growth of bifidobacteria and lactobacilli. Concurrently, the release of free ferulic acid by ET-DWF was almost three times higher respect to the control.

By the critical assessment of the intervention studies performed using cereal bran and whole grains, the hypothesis that the slow and continuous release in the gut of the dietary fibre bound antioxidants determines the health benefits of cereals, is illustrated. According to this picture the cereal antioxidant dietary fibre can be regarded as a suitable vehicle to bring phenolic compounds into the lower gut. These compounds cannot be absorbed when are bound to the polysaccharide moiety, becoming available for gut microflora. Moreover, those linked to the soluble dietary fibre can be hydrolyzed by bacterial esterases and absorbed into the bloodstream where they might prevent LDL oxidation, thus exerting several beneficial effects.

For these reasons it is advisable to convert IDF into SDF to maximise the possible health benefits of cereal DF phenolic compounds. This goal can be achieved by different approaches and in the last part of the work, new perspectives and technological possibilities to enhance the health potential of this cereal component will be also highlighted.

S302 09.30–10.00

Bioavailability of lignans: pharmacokinetics and effects of processing

Peter Hollman

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Lignans are phenolic constituents of plant cell walls which might contribute to the beneficial health effects of whole grains. In order to be able to evaluate the health impact of these compounds, it is necessary to measure the lignan exposure of humans. Because health effects are brought about by the lignans that are available for processes inside the body, it is important to measure the internal exposure of the body rather than the external exposure as determined by the mere consumption lignans. External exposure can only be translated to internal exposure with knowledge on pharmacokinetics and bioavailability.

Human pharmacokinetic data of a purified lignan will be shown. After ingestion, major metabolites, which are supposed to be the active compounds, are slowly formed, reaching maximum concentrations after 15-20 h. Mean residence time inside the body amounts to 21 – 36 h, and elimination half lives range from 4-13 h. These data indicate that lignans accumulate in plasma when consumed 2-3 times a day, resulting in steady state plasma values. Therefore, plasma concentrations are good markers for internal exposure,

The food matrix is a very important determinant of absorption, and food processing might be a good way to increase the bioavailability of lignans. Flaxseed is a very rich source of lignans. We studied whether crushing and milling improves the bioavailability of the lignans contained in the seeds. In a human study, it was shown that crushing of the seeds increased lignan bioavailability 1.5 fold, whereas milling increased it 3.5 fold.

In conclusion, knowledge on bioavailability and pharmacokinetics is important to evaluate the health impact of these phytochemicals.

S303 10.30–10.50

Challenges in cereal folate analysis

Susanna Kariluoto, Vieno Piironen

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Cereals contribute considerably to the dietary intake of folate. Folate contents differ markedly according to the cereal species, and processing such as fractionation, baking, and thermal treatments also has significant effects. Folate in cereals exists as several folate forms (vitamers) with varying polyglutamyl chain-length and different stabilities. Folates are susceptible to heat, light, and oxygen, and their concentrations in food are often low. Ensuring folate stability during sample storage, pre-treatments, and analysis requires special attention. In addition, folates may be physically entrapped in the matrix, and efficient purification is required for the use of HPLC methods in cereal folate determination.

Folate values in food composition tables have often been established by using microbiological assay, which is the method of choice in official methods of food folate analysis. The microbiological assay gives a single value, total folate, whereas folate vitamers and number of glutamyl residues can be analysed by HPLC. Specific data on vitamers are needed to evaluate not only the changes in food processing and storage but also the bioavailability, which can be affected by the polyglutamyl chain-length, food matrix, and the (in)stability of folates. HPLC also enables to differentiate between endogenous folates and added folic acid that is used in food fortification.

HPLC methods tend to give 20 to 30% lower results than microbiological assay but the correlation between the methods varies. It seems that particularly in thermally processed samples the discrepancy can be great and can not be explained merely by uncertainty related to low vitamer concentrations. During food processing and folate analysis some vitamers may convert to others, and there may thus exist unidentified folate vitamers that are not quantitated by HPLC. On the other hand, it is possible that micro-organism used in the microbiological assay responses unequally to

different vitamers or its growth is stimulated by non-folate compounds. The wide variation in intercomparison studies indicates the need for careful validation and standardisation of methods. HPLC methods may not yet be at the stage for routine folate analysis but together with mass spectrometric methods they are able to elucidate problems related to folate stability and analysis.

S304 10.50–11.10

Evaluation of the uptake of bioactive components from wheat in healthy adults

Ruth Price, Robert Welch

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There is now strong evidence that wholegrain foods protect against heart disease and certain cancers. The factor(s) responsible for these beneficial effects are not known. Apart from being high in cereal fibre, wholegrain products are also rich in bioactive components including phenolic phytochemicals and micronutrients such as tocopherols, betaine, choline and folate.

The aim of the present study was to evaluate the post-meal uptake of tocopherol and phenolic antioxidants, and the physiological methyl donors; folate, betaine and choline, from the aleurone fraction of the wheat grain at two levels of processing. The first study used maximum practicable doses of minimally processed aleurone, and the second study incorporated the same quantity of aleurone into a baked bread roll.

The two studies were of a cross-over design, where subjects participated on two occasions, at least one week apart. In the first study fourteen healthy subjects (7 male; 7 female; age 27.8 (SD 6.5) years) consumed either 50g wheat aleurone boiled in water or a balanced control product, after an overnight fast. Thirteen healthy volunteers (6 male; 7 female; age 33.9 (SD 6.0) years) completed the second study consuming either an aleurone-rich bread roll or a balanced control bread roll. In both studies blood samples were collected at baseline and at 30, 60, 120 and 180 minutes post-meal. Plasma samples were analysed for tocopherols (HPLC), the main wheat phenolic, ferulic acid (LC-MS/MS), folate, choline and betaine (LC-MS/MS).

Overall results showed that wheat aleurone can impact significantly on postprandial betaine and ferulic acid plasma levels, and that processing had little effect on uptake. This may be of importance to health given the ability of dietary betaine to lower plasma homocysteine, an independent risk factor for cardiovascular disease, and the antioxidant and anti-inflammatory potential of ferulic acid. Whether these observations would be maintained with regular consumption of aleurone-rich products, and possible longer-term health benefits, requires further investigation.

This study is financially supported by the European Commission 6th Framework Programme project HEALTHGRAIN (FP6-14006).

S305 11.10–11.30

Whole wheat sourdough bread: effect of bifidobacterial strain as starter culture for sourdough fermentation

Laura Sáez Andreu, Juan Mario Sanz Penella, Juan Antonio Tamayo Ramos, Monika Haros

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The whole grain or fractions of cereal grain can be modified by sourdough fermentation to improve nutritional value or promote healthiness of cereal foods. The whole wheat sourdough has great potential to modify the digestibility of starch by raising the lactic and acetic acid levels and increasing the mineral bioavailability. During sourdough fermentation, lactic acid bacteria produce metabolites which have been shown to have a positive effect on the texture, flavour and staling of bread, exopolysaccharides, and/or enzymes. Many new interesting applications for sourdough remain still to be explored, such as the use of *Bifidobacterium* starter culture which could produce new bioactive compounds. The objective of this study was to develop new cereal-based products, with increased nutritional quality, by using bifidobacteria from human origin as a new starter in whole wheat sourdough, and evaluate the bread quality. The effects of the use of the bifidobacterial strain as starter in sourdough bread was comparatively evaluated with control ones (yeast and/or acidified sourdough with antibiotics). Sourdough was prepared with cellular suspension containing 10^8 CFU/g of *B. pseudocatenulatum*, incubated at 37ºC for 20 h in anaerobic conditions. Two different sourdough levels (10 and 20%) were used in bread dough preparation. The sourdough fermentative parameters (pH evolution, volume, total titrable acidity [TTA], lactic and acetic acids), bread technological and nutritional parameters (moisture, slice shape, crumb firmness and structure, crust and crumb colour, pH, TTA, lactic and acetic acids, and *myo*-inositol phosphates) were analysed.

Whole wheat breads in the presence of the selected human bifidobacterial strain had similar technological quality as the control sample, with the exception of specific bread volume and slice shape, which decreased significantly. Sourdough bread fermented with the bifidobacterial strain significantly increased the levels of organic acids in dough and final product, which are involved in lowering the glycaemic index. Moreover, the inoculation of the bifidobacterial strain contributed to the fermentation process, activating the cereal endogenous phytases resulting in dough with significantly lower level of InsP_6. Preliminary studies about acceptance of consumers demonstrated that the 10% level of sourdough for whole wheat bread product was acceptable to consumers as control samples.

S306 11.30–11.50

Production and nutritional evaluation of wheat bread fortified with germinated wheat seedlings

Peter Koehler[1,2], Gaby Andersen[1], Veronika Somoza[3]

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Several epidemiological studies show that whole-grain cereals have the ability to protect against the development of type II diabetes. These effects are thought to result mainly from an increased intake of dietary fibre. The knowledge about the contribution of non-fibre compounds to the bioactivity of whole grains is scarce, although several strategies i.e. germination of plant seeds are applied to elevate bioactive compounds. The aim of the present work was to study whether a wheat bread fortified with germinated wheat seedlings positively affects glucose regulating factors compared to a control wheat bread in healthy volunteers. Firstly, wheat kernels were germinated at 20°C for 102 h and used as an ingredient in the production of bread. 30% of flour was replaced by germinated material based on dry mass. Several approaches to limiting the detrimental effects of germinated cereals on the functional properties were made. Bread with good textural characteristics was obtained when germinated wheat kernels were pasteurised (3 min, 70°C) before they were added to a sourdough formulation. At the beginning of the nutritional study, a 75 g-OGTT (oral glucose tolerance test) was performed. Subsequently, the subjects received 300 g of a control wheat bread containing imbibed wheat kernels or wheat bread containing germinated wheat kernels for nine days. After the experimental diets, again a 75 g-OGTT was performed. Venous blood samples were collected and selected parameters of glucose homeostasis in the plasma were analysed. During the control bread period, insulin sensitivity increased severely. This effect was further positively influenced by the experimental bread. Consumption of 300 g of the control bread for nine days did not lead to different plasma glucose levels, whereas a daily intake of 300 g of the experimental bread for nine days lowered plasma glucose concentrations in the fasting as well as in the postprandial state.

It seems feasible that other ingredients than fibre were responsible for the glucose lowering effect as the content of phenolic compounds in the experimental bread was increased by 40% compared to the control bread. Thus, it may be possible that phenolic compounds had affected glucose metabolism during the experimental bread period.

S307 11.50–12.10

Development of whole grain high lutein functional foods

El-Sayed Abdel-Aal

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Lutein, a dihydroxyl carotenoid, constitutes the main yellow pigment in wheat. It has been linked with a reduced risk of age-related macular degeneration (AMD), cataracts and cancer. It also promotes health of humans particularly eyes and skin. This research was aimed at the development of whole grain high lutein functional foods. High-lutein whole wheat flours, wheat/corn blends and lutein-fortified whole grain flours were processed into bread, cookie and muffin. Stability of lutein during processing and subsequent storage was investigated. Digestibility and antioxidant properties were also evaluated in vitro. Carotenoids and their geographic isomers in the developed foods were separated, identified and quantified by LC-Vis/UV and LC-MS analyses. In raw wheat and corn, all trans lutein was the predominant isomer along with small concentrations of cis isomers. In general, baking caused a significant reduction in all trans lutein by about 50–65% depending upon product type and original concentration of lutein. Baking also resulted in the formation of cis isomers which was concentration dependent. Storage of bread, cookie and muffin at room temperature had slight effects on lutein concentration and isomerization. Despite the substantial reduction in lutein, the fortified products still had reasonable amounts of lutein per serving (0.5-1.0 mg/serving) which could be used to manage AMD through the enhancement of lutein daily intake.

S308 12.10–12.30

Bioactive molecules in cereals and influence of processing on their content

Marina Carcea, Giuseppe Maiani, Elena Azzini, Alessandra Durazzo, Valentina Narducci, Anna Raguzzini

National Institute for Research on Food and Nutrition (INRAN), Roma, Italy

Several recent studies have assigned to cereal grains and to wholemeal cereal products a protective role in human health due to their content of bioactive compounds (polyphenols, phytosterols, βglucans, lignans, etc). As known, the content of these molecules varies depending on genetics, growing conditions (including environment and agronomic regimes) and post-harvest treatments as far as grains are concerned, whereas processing conditions play a key role in determining their amount that can be found in cereal products consumed by the population. The assessment of their bioavailability is a further step that ought to be considered when studying these compounds in human nutrition.

Several cereal species are widely consumed in Italy as traditional (bread, pasta, grains in soups, gruels, polenta, etc.) and modern products (breakfast cereals, bars, bakery products, etc.). Some are traditionally consumed as wholemeal products others are manufactured by utilizing refined milling fractions.

In order to improve our knowledge on the content of bioactive molecules present in cereals and their products consumed by the Italian population, several studies where undertaken to characterize and quantify some groups of bioactive substances, in particular phenolic acids, carotenoids and lignans, in grains of different species and cultivars (soft wheat, durum wheat, rice, emmer, spelt, triticale, maize, barley, oat, rye) and to determine the total antioxidant capacity in the same grains. The results of these studies are reported in this work. The molecules of interest were suitably extracted and separated by HPLC. Phenolic acids and lignans were also quantified in products deriving from primary and secondary processing of cereals (flours, dehulled grains, pasta). For pasta and rice products and for some molecules, analyses were also performed on cooked samples ready for consumption.

Parallel Session 4 • Friday, March 27, 2009 09.00–12.30

Effect of new whole grain introductions, consumer response, regulations, and labelling; E.U. vs. U.S.A.

Chairs: Julie Jones, College of St. Catherine, U.S.A.; Len Marquart, University of Minnesota, U.S.A; Clare Leonard, Cereal Partners Worldwide, U.K.; Rob Hamer, Top Institute Food and Nutrition, the Netherlands

S401 09.00–09.30

Scientific substantiation of the health benefits of whole grain

David Richardson

DPR Nutrition, Croydon, U.K.

Codex Alimentarius, the European Food Safety Authority (EFSA) and the US Food and Drug Administration are among the organisations that have recently developed recommendations and detailed scientific and technical guidance for the preparation and presentation of an application for authorisation of a health claim. For example, the new European regulations require that each application covers only one relationship between a nutrient or other substance, or food or category of food and a single claimed effect, that substantiation shall take into account the totality of the available data and weighing of the evidence, and the law sets out precisely the structure of a scientific dossier consistent with EFSA guidelines for any application for a health claim. The European law seeks EFSA's advice on the extent to which (a) the claimed effect is beneficial for human health, (b) a cause and effect relationship has been established between consumption of the food and the claimed effect in humans, (c) the quantity of the food and pattern of consumption required to obtain the claimed effect as part of a balanced diet, and (d) the specific study group(s) in which the evidence was obtained is representative of the target population for which the claim is intended. EFSA has now published several opinions, and the reasons for rejection of a health claim include (a) the foods/food constituents were not sufficiently characterised, (b) the effects of food matrix, processing and stability were not sufficiently characterised, (c) a cause and effect relationship was not established, (d) lack of a systematic literature review and no specific inclusion/exclusion criteria, and (e) criticism of study designs, absence of power calculations, lack of intervention trials and no lowered risk factor.

The present paper will discuss (a) the impact of new laws and guidelines for substantiation of health claims in the context of the European integrated project HEALTHGRAIN, which is relevant to the development of healthy grain-based products, including whole grains, (b) the source and nature of substantiating evidence including human intervention and observational studies, and (c) the future challenges to researchers to develop more rigorous scientific methodologies for human studies with trial designs, executions and interpretations that fit the purpose of substantiating health claims.

S402 09.30–10.00

Promoting cereal grain and whole grain consumption—An Australia perspective

Trish Griffiths

Go Grains Health & Nutrition Ltd., Sydney, New South Wales, Australia

Go Grains Health & Nutrition (GGHN) aims to stimulate consumption of grain-based foods in Australia through a program of activities that promote increased awareness and understanding of the role of grain foods in a healthy diet. Strategies are developed to drive the Australian dietary guidelines' message that a healthy diet for all age groups (over 4 years old) should include at least 4 serves of grain-based foods every day (1 serve is 2 slices of bread or equivalent). The 'Go Grains 4+ serves a day' program promotes both refined and wholegrain foods through media communications, website information, resource development, an education strategy and food industry involvement. It engages food industry through availability of a '4+ serves a day' logo for members to use on products that meet specific eligibility criteria. It extends to Australian schools through the Go Grains Kids Design Challenge which engages students (with positive flow-on to teachers and parents) in researching and developing media tools that promote the '4+ serves a day' message to their peers.

Growing awareness of the health benefits of wholegrains in Australia is helping to stimulate a resurgence of interest in the grain food category (attitudes to 'refined' foods such as white bread remain quite negative post the 'low carb diet' trend). Manufacturers are responding with new wholegrain product launches and product re-formulations. There has been a significant shift in bread sales from white to wholegrain but little overall increase in total bread sales. 'Wholegrain' claims on pack are becoming more common, especially for breads and breakfast cereals, in a regulatory environment that does not yet permit health claims on pack. GGHN has taken a lead role in developing an industry standard for wholegrain claims on pack in the absence of formal government regulation.

There are limited data publicly available to describe consumption of grain-based foods in Australia. The findings of a 2009 survey commissioned by GGHN, together with the findings of the 2007 Australian National Children's Nutrition and Physical Activity Survey, help provide an insight into consumption trends.

S403 10.30–10.50

Whole grain structure, chemistry, and physiology—What do we need to know?

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There is little doubt that consumption of whole cereals and other grains confers benefits to consumers, and a number of studies support the notion that health and wellness outcomes correlate positively to levels of whole grains in the diet. These benefits may be functions of dietary fiber levels, improved protein quality, excellent antioxidant and vitamin levels, or they may simply reflect the benefits of consuming these components in combination. What is not clear, however, is just how we must process whole grains to ensure that we are in fact producing true whole grain products, nor is it obvious what current common processes may do to the nutritional quality of whole grain products. Although there are a number of strong assessments of the effects of whole grains on health, the biochemical evidence supporting many whole grain "benefits" is often indirect, circumstantial, or poorly defined, at best, although an enormous number of studies have added greatly to our understanding of grain composition and structure. It is obvious from these analyses that we are now much better equipped to define the physiological effects (and benefits) of whole grains, providing that we attempt to integrate appropriate epidemiological, genetic, and biochemical assessments. Some of the needs and issues will be discussed.

S404 10.50–11.10

Evaluating the effect of applying the FDA definition of whole grains to health claims for risk reduction of cardiovascular disease and diabetes

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The U.S. Food and Drug Administration (FDA) defines whole grains as consisting of the intact, ground, cracked or flaked fruit of the grains whose principal components—the starchy endosperm, germ and bran—are present in the same relative proportions as they exist in the intact grain. We evaluated the effect of applying the FDA definition of whole grains on the strength of scientific evidence in support of claims for risk reduction of cardiovascular disease (CVD) and diabetes. We concluded that using the FDA definition for whole grains as a selection criterion is limiting because the majority of existing studies often use a broader meaning to define whole grains. When considering only whole grain studies that met the FDA definition we found insufficient scientific evidence to support a claim that whole grain intake reduces the risk of CVD. However, a whole grain and CVD health claim is supported when using a broader concept of whole grain to include studies that included intake of bran and germ as well as whole grain. The scientific evidence on the relationship of whole grain consumption and diabetes is suggestive but inconclusive whether or not the definition of whole grains was in accordance with that of the FDA. This type of analysis is complicated by variation among different types of whole grains due to their diversity in nutrients and bioactive components.

This project was sponsored by Kellogg Company, U.S.A.

S405 11.10–11.30

Increasing whole grain consumption—Experiences of a global food company

Brigid McKevith[1], Maria Mondragon[2], Sarah Richards[3], Nilani Sritharan[4], Lydia Midness[3]

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Introduction

Cereal Partners Worldwide (CPW) is one of the largest global breakfast cereal companies. For the last 3 years it has focused on highlighting whole grain as a main component of its products.

Experiences

CPW's whole grain journey began in the UK in 2005 and since then to many other countries around the world. Communication with consumers has been at the centre of the campaign. However because the "whole grain" concept is sometimes unknown and cultural differences exist regarding whole grain foods, the messages have been adapted for use in different regions.

Healthcare professionals have been key allies when it comes to communicating the details of the whole grain message and specific programmes aimed at informing them of the latest scientific evidence of whole grain and health have been an important part of the strategy.

Where possible, linking whole grain messages to official whole grain recommendations has been useful for CPW's strategy.

Challenges: In addition to the technical challenges posed when increasing the whole grain content of some products, one of the main challenges is the lack of quantitative whole grain recommendations in most parts of the world. Also the absence of an official definition of the term whole grain leads to confusion by healthcare professionals,

policy makers and consumers, as inconsistencies exist between products that are labelled as whole grain. Opportunities: CPW has found some opportunities to continue to communicate to consumers about the benefits of whole grain. It will continue to work with a range of stakeholders to encourage and support increased whole grain consumption.

S406 11.30–11.50

Whole grain consumption and dietary change in the 12-month period following participation in a randomised, controlled whole grain intervention (the WHOLEheart study)

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Background: A number of health messages encourage the general population to consume more wholegrain (WG) foods both in Europe and the US. The impact of WG intervention on long-term changes to the diet of low WG consumers has not previously been described

Methods: 266 participants, who consumed less than 30g/d WG at baseline, had BMI>25 but were otherwise healthy, completed a randomised, controlled 16-week dietary intervention testing the impact of the inclusion of WG foods on measures of cardiovascular disease risk (the WHOLEheart study). Participants were contacted one-, six- and twelve-month post-intervention, and asked to fill out a food frequency questionnaire (FFQ) to assess their dietary intake. The same FFQ had been used to assess dietary intake during the intervention period. Comparison between post-intervention and baseline data was carried out by non-parametric, two-tailed T-test.

Results: During the intervention period, WG participants increased WG consumption by >70g/day. Return rates for FFQs were 55%, 53% and 47% at one-, six and twelve-month time-points respectively. WG intake was <20g/day for control and WG participants at baseline. This did not significantly change in the control group (P>0.2) over the twelve-month post-intervention period. Mean (SD) WG intake for WG participants remained significantly higher (P<0.001) than baseline (18.7 (19.3)) over the 12-month post-intervention period (at 1-month = 47.8 (28.8), 6 months 44.2 (33.6), 12 months 35.6 (29.1)). Those from the WG intervention group maintained a significantly higher intake of dietary fibre (P<0.025); consumed meat significantly less frequently and had a lower estimated fat intake at all time-points (P<0.005 and <0.02 respectively) compared with the control group.

Discussion: Dietary intervention with WG foods in previous non-WG consumers resulted in an approximate doubling of WG intake 12-month post-intervention compared with baseline. The results show that after imposed introduction of WG foods into their diets in the intervention, participants continued to consume these foods voluntarily and appear to have an improved dietary profile. *This study was funded by the UK Food Standards Agency (N02036).*

S407 11.50–12.10

Starchy foods and their characteristics—experimental evidence for a protective effect on type 2 diabetes mellitus?

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In prospective cohort studies the consumption of whole grain foods or foods that elicit a low postprandial glucose response (low glycemic index food) is negatively associated with the development of type 2 diabetes (T2DM). The aim of this systematic review was to evaluate the experimental evidence from short and long-term animal and human intervention studies for a beneficial effect of the specific characteristics of those foods on factors involved in the pathogenesis of T2DM. Medline and EMBASE from 1990 till April 2008 were searched and 8773 potential studies retrieved. In total 42 studies met the inclusion criteria.

In rodent studies dietary interventions of 3 – 25 weeks with slowly digestible starch and resistant starch resulted in lower fat mass or decreased adipocyte size and improved glucose tolerance (after ≥ 5-weeks) despite the same body weight compared to diets with rapidly digestible starch without resistant starch.

In persons with impaired glucose tolerance diets with moderately increased amount of cereal fiber (3 weeks – 6 months; ca. 13 g/day) consistently had a beneficial effect on glucose tolerance and insulin sensitivity. After interventions (3 days – 12 weeks) with foods eliciting low postprandial glucose response and/or rich in dietary fiber no consistent effect was found on these parameters in healthy persons. However, the glucose response after a standard breakfast consistently was decreased when an evening meal was ingested that was rich in certain cereal fibre and/or resistant starch independent of the glycemic index of those foods.

In animal studies increased consumption of cereal fibre improved oxidative stress defence, whereas human studies measuring markers of inflammation showed no effect.

Few studies assessing adipokine secretion and reported varying findings.

In conclusion, to date experimental evidence suggests that increased cereal fibre or resistant starch consumption beneficial influences risk factors for the development of T2DM. Colonic fermentation of indigestible carbohydrates and/or bioactive compounds associated with cereal fibre seem to have a more important contribution to that effect than reduction of the postprandial glucose response.

S408 12.10–12.30

Systematic review and meta analysis of the relationship between whole-grain consumption and weight management

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Background: Whole grain is recognised as an important component of a healthy diet, however with the rising incidence of obesity we considered that assessment of the evidence relating to its role in weight management was timely.

Objective: This systematic review of the scientific literature and meta analysis was conducted to identify and quantify the effect of whole grain consumption on measures of weight gain and risk of obesity.

Design: Scientific databases were searched for cohort studies that measured weight gain and whole grain intake during the period 1995-2008; other observational studies that met pre-defined criteria were also retained for analysis. Weighted mean effect sizes were calculated for net changes in weight or weight gain, risk of obesity and central adiposity using either fixed or random-effect models.

Results: The primary outcome, weight gain, calculated from 5 cohorts, (76912 subjects) followed for circa 8 years, was 0.568kg (95%Cl:-0.43, -071kg) lower in those consuming most whole grain; P<0.0001. Whole grain consumption reduced the risk of overweight or obesity (BMI>25) when calculated as either OR (5 studies) or RR (2 studies);. OR = 0.850 (95%Cl 0.71, 1.02), RR = 0.809, (95% Cl 0.67, 0.975), *P*<0.05 and combined risk ratio was 0.83 (95% Cl 0.73, 0.95); *P*<0.005. A higher intake of whole grain resulted in lower waist:hip ratio or waist circumference (WC) equivalent to 19cm reduction in WC.

Conclusion: A higher intake of whole grain is associated with less weight gain, central adiposity and risk of obesity.

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