Coordinating global research for wheat

Improving wheat quality for processing and health EWG

Annual report and action plan

NAME OF EXPERT WORKING GROUP
Improving wheat quality for processing and health

LEADERSHIP & AUTHORSHIP	
Chair	Name (Organisation, Country)
Vice-Chair(s)	Name (Organisation, Country), Name (Organisation, Country)
Report Authors	Tatsuya M. Ikeda (NARO, Japan), Angéla Juhász (HAS, Hungary), John Rogers (Universidad Nacional del Centro de la Provincia de Buenos Aires, Argentina), Peter Shewry (Rothamsted Research, UK), Valérie Lullien-Pellerin (INRA, France), Sofia Chulze (Universidad Nacional de Rio Cuarto, Argentina), Ravindra Chibbar (University of Saskatchewan, Canada), Carlos Guzman (CIMMYT, Mexico), Gerard Branlard (INRA, France) and Roberto J. Peña (CIMMYT, Mexico)

MEETINGS HELD (please attach minutes of these meetings using the template provided)						
	Name	Date	Location	Duration	# EWG members expected	Estimated Cost (€)
Face-to-Face Meetings	12th International Gluten Biotechnology Workshop (informal)	September 2015	Perth	Two hours	Around 10	0
Other Meetings	Type (online, etc)	Date	Location	Duration	# EWG members present	Cost (€)

AIMS OF THE EWG
This EWG is aimed at maintaining and improving wheat quality and safety under varying environmental conditions. Our expert group will focus on wheat quality and safety in the broad sense, including seed proteins, allergens, carbohydrates, and nutrition quality including micronutrients, grain processing, food safety, genetic resources and gene nomenclature. We will also share genetic resources and unify gene

nomenclature related to grain quality.

Aims of the different tasks

Seed proteins: It is well known that allelic variation for the high- and low molecular weight glutenin subunits strongly affects gluten strength and dough extensibility. However, technical difficulties in allelic identification due to the complexity of the protein profile produced by each cultivar and the use of different nomenclature systems in different laboratories has historically interfered with information exchange between research groups, a situation exacerbated by the vast number of possible profiles found in different cultivars due to the multi-allelic nature of the principal loci encoding gluten proteins (*Glu-1*, *Glu-2, Glu-3*, *Gli-1* and *Gli-2*). For the *Glu-3* alleles, a previous collaboration was established to unify criteria across laboratories and to compare different methods of allelic identification. The results gained from the across-laboratories studies have shown that the proteomics and marker-based methods used can be regarded as complementary techniques for allelic identification. We will seek to continue to address remaining analytical challenges and bioinformatic data mining, and will include other seed proteins (e.g. puroindolines, avenin-like proteins and polyphenol oxidase), placing the findings in the context of the Catalogue of Gene Symbols for Wheat and, with unified criteria, initiating work aimed at better defining the relationship between specific seed proteins and processing quality attributes

Allergy and intolerance: Wheat-related food disorders cover a range of different molecular mechanisms. Food and respiratory allergies and intolerances, such as celiac disease, dermatitis hepatiformis and gluten ataxia, are related to proteins and non-protein components of the wheat seed. The identification of these gluten and non-gluten proteins or other components is of major importance, considering increases in the diagnosis of these conditions globally. The understanding of toxic and allergen compounds at genotype level, the identification of seed protein types with low epitope content and characterization of their stability of expression under different biotic and abiotic stress conditions will enhance our knowledge and consequent ability to identify genotypes with special characteristics. Furthermore, it will help us to understand whether wheat seed proteins, and especially gluten proteins, act as triggering molecules leading to the development of adverse reactions. Multidisciplinary methods, such as proteomics, biochemistry, structural biology, human and wheat genetics, immunology, gastroenterology and bioinformatics, will be used to explore these issues.

Carbohydrates: Carbohydrates account for 70-80% of grain dry weight. In cereal grains, starch is the major reserve carbohydrate present as water-insoluble granules with an internal lamellar structure. A starch granule is made up of two glucan polymers, amylose and amylopectin, along with traces of lipids and proteins. The increase in amylose concentration has been associated with resistant starch (less digestible) formation in foods. In recent reports, starch has now been classified as digestible, slow digestible and non-digestible, which in our opinion is a reflection of the diversity of amylose structure in native starches.

For non-starch polysaccharides, grains contain several components, such as arabinoxylans and beta-glucans, present in the endosperm cell walls of cereal grains and significantly affecting the flour/meal properties and their utilization. The predominant component of the starchy endosperm cell wall in wheat is arabinoxylans and a very minor amount of β-glucans. Since humans do not produce any autochthonous enzymes that degrade the cell wall polysaccharides, β-glucans and arabinoxylans contribute very little to the digestible energy. Depending on the source and methods of grain processing/preparation (isolates vs. grain fractions vs. hydrolyzates), both polymers possess properties of soluble and/or insoluble fiber. Water soluble β-glucans and arabinoxylans, due to their thickening properties, are thought to enhance viscosity of the digests in the small intestine and to impair dispersion and mixing of the food mass with the fluid layer adjacent to the mucosal surface. The beneficial effects of β-glucan in reducing the risk of coronary disease are well known, but so far the influence of β-glucan structure on the degree of disease prevention has not been documented. Similarly, there are no systematic studies on the dietary fiber structure and their effect on the incidence of disease reduction is not well understood.

The major emphasis of this subgroup is to characterize genotypes that vary in carbohydrate composition and concentration. Genomics strategies will be important in identifying genes, which will allow us to

develop perfect DNA markers for carbohydrate characteristics of choice. These variations will be correlated to their enzymatic digestibility to predict their influence on energy absorption by the human digestive system. Sharing these materials will provide opportunities to develop and utilize wheat varieties with modified amylose and amylopectin concentrations. The diverse germplasm and wheat cultivars can be developed for both calorie rich and calorie deficient regions of the world.

Processing: The first processing step, i.e. milling, is known to be determinant in the grain tissue distribution that does not occur respective to its origin. It is also found to depend on the selected genomic background and wheat growth conditions, at least with respect to the hardness loci *Ha* and factors affecting grain vitreousness, both of which impact the grain texture. Moreover, grain infection history and storage conditions potentially affect the grain tissue biochemical composition, mechanical resistance and functional and safety properties of the obtained fractions. Contamination by heavy metals within grain and in processed fractions is also our target. Understanding relationships between the structure and composition of grain tissue and their behavior during fractionation appears to be a key step in allowing the control of the composition and properties of the products. It could also allow the development of new processing strategies and the reduction of the energy input required. Thereafter, a better knowledge of the products resulting from first transformation could help to modulate the second processing step to obtain food products with required properties (health, sensory, shelf-life and safety). Complementary approaches that allow the building of relationships between the genome, the agronomical and postharvest conditions, as well as the generation of data related to the distribution of compounds of interest or detrimental for the products, need to be developed, in order to be able to develop new cultivars and to construct innovative, flexible and sustainable management strategies. Being located between the field and the fork, processing appears to play a key role in the adaptation or improvement of product quality.

In the first phase of the proposed EWG, the following studies are planned:

- In the context of sustainable processing, the possibility to adjust energy expenditure at each step needs to be considered.
- Due to new modes of agriculture that attempt to reduce pesticides and fertilizers, changes in the raw material composition (low protein content, mix of cultivars, wheat cultivars associated with leguminous grains) are expected. Adaptation of the process to these changes has to be undertaken.
- Use of the all parts of grains, as well as the wheat plant, must be developed and preferentially applied in a local areas.
- Monitoring of toxic minerals (e.g. Cd), as well as mycotoxins, spreading in processed fractions.
- Development of processes allowing the enrichment of nutritionally interesting compounds, use of non-adapted raw matter or recycling grain losses for transformation, if possible.
- Development of innovative products better adapted to consumer sensory and nutritional needs.

Nutrients and micronutrients: Wheat is an important source of dietary fiber, minerals and vitamins (notably B vitamins) in the human diet and also contains a wide range of bioactive phytochemicals, many of which have been proposed to have health benefits. We will determine the range of concentrations and compositions of these components in diverse wheat germplasm and partition this variation between effects of genotype, environment, and G x E interactions. It will allow us to select a standard cultivar set based on genetic relationships and fibre content. Mendelian and association genetic analyses of highly heritable components will identify controlling loci, facilitating the identification of controlling genes and establishment of markers for selection in breeding programs. The distributions of components in the grain and the effects of processing on their concentrations and availabilities will be determined. Collaborations with human physiologists and nutritionists will relate composition and processing to digestion and absorption in the GI tract and to physiological effects.

Food safety: Mycotoxins in human and animal food supplies have been a recognized safety issue for many years. Both bread and durum wheat are susceptible to fungal contamination at different stages of the food

and feed chains, pre- and post-harvest. Advances have been made over the last few years to reduce the impact of mycotoxins. The scenario of climate change, changes in cultural practices (non-tillage) and the increasing resistance of pathogens to chemical treatments requires us to focus on evaluating new strategies to reduce the impact of mycotoxins in the food and feed chains. Metabolomics can help us to understand better the plant–pathogen interaction, and it is also important to evaluate the natural occurrence of the original toxins and the masked mycotoxins, i.e. those derived from plant metabolism or formed during processing (such as DON 3 G), since these masked mycotoxins can contribute to the total toxicity to the humans and animals. To establish risk maps at a global level it is necessary to monitor the changes in the biodiversity of the toxigenic fungi in the different regions in which wheat is cultivated. Interactions between plant pathologists, breeders and food processing organizations will be important. Among the mycotoxins produced in wheat, the trichothecenes, mainly deoxynivalenol and their acetylated derivatives, are the main toxins of interest, although the aforementioned masked mycotoxins also need to be considered. Nonetheless, other toxins could be considered at a second stage, such as fumonisins, and toxins produced by *Alternaria* species. Strategies to reduce other contaminants, such as toxic minerals, also need to be considered.

Genetic resources and gene nomenclature: The expert working group will cover six major tasks related to wheat quality: seed proteins, allergens, processing, grain carbohydrates, nutrients including micronutrients, and food safety. The literature will be reviewed to reevaluate and update the Catalogue of Gene Symbols for Wheat and thus collate all known diversity for the topics described above. Where allelic variation has been previously identified for their controlling genes, not all known alleles have been characterized for their effects on quality attributes. The diverse materials for these traits will be collected and characterized for quality attributes in different laboratories, in order to attempt to close this knowledge gap, to evaluate novel alleles as they are identified and to analyse the effects of different breeding and environmental conditions on the associations revealed between allele and quality attributes. Allelic nomenclature will be formalized in collaboration with the Catalogue, and an updated list of all known allele-quality associations will be maintained in parallel with this document. Master sets of seeds will be developed and multiplied in International Germplasm Banks for their distribution throughout the wheat research community, through collaboration with the EWG on Global Wheat Germplasm Conservation and Use Community. Therefore, a main focus will be to introduce a new system to share materials through public gene banks, and the formation of a wider international group aimed at facilitating the resolution of the remaining problems in these fields.

2015 ACTIVITY REPORT

Reminder of **EWG action plan for the duration of the EWG, with flow-chart indicating timeline and outputs**

Objectives identified for 2015

1. Organising the Expert Working Group, including subgroups focusing on: seed proteins, allergies, intolerances and other negative impacts on health, carbohydrates, processing, nutrition and health benefits, and food safety.

2. Establishing an advisory board.

3. Setting up a communication network among all participants using a mailing list and/or SNS to exchange information and discuss related issues.

4. Review current research activities on the above topics, including national and internationally funded programmes and key research groups and activities (month 12).

5. Organise focused workshops to develop research agendas for the above topics, including targets,

resources required and potential sources of funding (month 18). 6. Development of a plant material collection and distribution system, and provision of material for the different research groups (month 18). 7. Development of a platform for data sharing and exchanges (month 18). 8. Organise EWG sessions at relevant international meetings: Gluten Biotechnology Workshop (Perth, Sept 2015), International Wheat Conference (Sydney, Sept 2015), AACC, ICC and Eucarpia meetings (ongoing).
Progress against aims in for 2015
1. Organising the Expert Working Group, including subgroups focusing on: seed proteins, allergies, intolerances and other negative impacts on health, carbohydrates, processing, nutrition and health benefits, and food safety. 2. Organising EWG sessions at 12th International Gluten Biotechnology Workshop (Perth, Sept 2015). A poster presentation at International Wheat Conference (Sydney, Sept 2015) 3. Selecting members (in progress): 53 members (9 applicants were not selected among 62 applicants) 4. Listing our working plans including core members for each subgroup (in progress). Refer to attached file. 5. Deciding the venue and date of our first meeting: 25th to 27th April in INRA-Paris.
Outputs and deliverables in 2015
Should include input into the Strategic Research Agenda and implementation plans as well as recommendations on how wheat research could be done more efficiently at the international level. May include other items such as position papers, gap analyses (e.g. using SWOT or PESTLE), work plans, research or funding proposals, publications, presentations etc.
Contribution to Wheat Initiative objectives (http://www.wheatinitiative.org/about/objectives)
Links established with other Wheat Initiative activities
In the WIC held at Sidney, there was the possibility for some of us to meet and interact with the leaders of other EWG and discuss about common projects. It is being discussed the possibility of celebrating a workshop with scientists of the EWG in Wheat Information System to support them in the correct annotation of wheat quality related genes in the wheat genome.
Additional activities

ACTION PLAN FOR NEXT TWO YEARS						
Meeting planned for 2016						
Face-to-Face Meetings	Name	Date	Location	Duration	# EWG members expected	Estimated Cost (€)
	The first meeting	April 25-27th	INRA-Paris, France	3 days	30	20,000
Other Meetings	Type (online, etc)	Date	Location	Duration	# EWG members expected	Estimated Cost (€)

Priorities identified for 2016-2017

1. Defining the structure (members).

   Calling researchers from developing countries to join the EWG.

2. Developing the agenda and objectives of the EWG.

   Defining activities and objectives of each subgroup and how the different subgroups can interact between them to reach the proposed objectives.

3. Setting up a communication network among all participants using a mailing list and/or SNS to exchange information and discuss related issues.

4. Development of a plant material collection and distribution system, and provision of material for the different research groups.

5. Organise EWG sessions at relevant international meetings (e.g. 15th ICC International Cereal and Bread Congress in Istanbul).

6. Presentation of the EWG at the 5th International Symposium on Fusarium Head Blight and 2nd International Workshop on wheat Blast (Florianopolis-Brazil April 2016)

7. Participation in a Mycokey project, approved by European Commission working on food safety on wheat.

8. Establishing links and common projects with other EWG.

Expected outputs and deliverables for 2016-2017

1. Establishing the EWG including members from developing countries.

2. Defining the agenda and objectives of the EWG.

3. Selecting standard sets for individual targets related to quality and safety (e.g. gluten proteins).

4. Selecting standard methods to evaluate quality and safety.

Timeline of activities for 2016-2017

Meetings organized in 2015

	Meeting 1
Location	Perth
Date/duration	September 2015
# attendees	10

Meetings planned in 2016

	Meeting 1
Location	Paris
Date/duration	25-27 April 2016