Coordinating global research for wheat

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EXPERT WORKING GROUP TOPIC SUBMISSION

Expert Working Groups (EWG) are established where a particular topic of direct relevance to the Wheat Initiative would benefit from bringing together experts in that specific field. The Wheat Initiative would provide them with a platform for discussion, information sharing, consideration of specific problems, identification of research priorities and gaps. The EWG should have clear objectives and these could include (but are not limited to) specific activities such as contributing to the development of the Wheat Initiative Strategic Research Agenda, producing a position paper for publication or addressing a particular challenge through a research programme. Each EWG will be established for an initial defined period. The minimum output should be annual reports to the Scientific Board for dissemination to the Research Committee, the Institutions' Coordination Committee and the wheat research community through the Wheat Initiative website.

Expert Working groups are established following the attached flow diagram. Organised consortia addressing wheat research challenges can be endorsed by the Wheat Initiative as EWGs following the same process. EWGs will be set up after approval of the submitted proposals by the Research Committee or the Institutions' Coordination Committee, each in its area of expertise (science or research organisation/funding). An open call for members of the EWGs will be organised on the Wheat Initiative website. Research priorities established by EWGs and endorsed by the Research Committee will constitute a port-folio that will be available to the Institutions' Coordination Committee members to tackle priorities together or independently in each country.

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Improving wheat quality for processing and health		
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Summary

This EWG is aimed at maintaining and improving wheat quality for processing and health under varying environmental conditions. It will focus on wheat quality in the broad sense, including seed proteins, carbohydrates, nutrition quality including micronutrients, grain processing and food safety. Bioactive compounds will be considered, both those with negative effects as problems to be resolved, such as allergens and mycotoxins, and those with positive effects to be exploited, such as antioxidants and phenolic compounds. In general, the potential for including wheat in the human diet as a means of promoting health will be addressed. The group will also share genetic resources and unify gene nomenclature related to grain quality.

The EWG will play a vital role to advance the research area of grain quality and apply scientific knowledge to develop improved varieties of wheat with desirable grain quality attributes for a wide range of end-uses. It will build on existing basic and applied knowledge and expertise, while linking with and utilizing outputs from other international initiatives, wheat research organizations and other Wheat Initiative EWGs.

Detailed description (5 pages maximum)

Rationale

In the context of climate change and a rapidly increasing urban population demanding ready-to-use foods, it is necessary to develop new wheat cultivars with disease resistance, high and stable yield, and improved processing quality in a sustainable context, particularly under varying environmental conditions that result in heat or drought stress. The rapidly expanding wheat genome sequence information that is becoming available provides opportunities to develop DNA based markers to accelerate wheat breeding by selecting and introducing genes related to improved grain quality. Our expert group will focus on wheat quality in the broad sense, including seed proteins, allergens, carbohydrates, nutrition including seed proteins, carbohydrates, nutrition quality including micronutrients, grain processing and food safety.

With regard to seed proteins, allelic variation for gluten proteins (glutenin subunits and gliadins) is a major determinant of differences in dough viscoelastic properties observed between cultivars of both bread wheat and durum wheat. Other seed proteins, for example, puroindolines involved in grain hardness, are also critical determinants of flour milling and dough properties. Some wheat proteins may cause allergic reactions in some individuals. Identifying and predicting allergenic motifs using genomics and proteomics will help us better understand these seed components. This information will help to identify genotypes suitable for special health related requirements. Carbohydrates are major components of wheat seeds. Variation in amylose and amylopectin composition affects food processing conditions, as well as the texture, shelf-life and digestibility of end products. Non-starch carbohydrates are the major components of dietary fiber, including β-glucan and arabinoxylan, which are of interest in relation to reducing obesity, the incidence of cardiovascular disease, type 2 diabetes and some forms of cancer. The prebiotic activity of some carbohydrates can be helpful to the digestive system and its microbiome. Wheat is also an important source of vitamins (notably B vitamins), minerals (notably Fe, Zn Se) and phytochemicals. Understanding variation in content and composition is necessary for their efficient utilization and the consequent enhancement of their beneficial health effects. Moreover, processing, including flour milling, plays an important role in determining the availability, and functional (in processing) and physiological effects, of these components. We will focus on this aspect in close collaboration with other subgroups. In response to social demands, we will also work on food safety by minimizing exposure to mycotoxins and heavy metals by developing biological and processing methods.

The objectives of the proposed EWG are to maintain and improve wheat quality for processing and health, and share advanced knowledge, important materials, analytical methods and allelic nomenclature among researchers around the world. The international research group as an EWG under the Wheat Initiative will be critical to the advancement of the research area of grain quality and to the promotion of collaboration with plant breeders aimed at incorporating the knowledge to develop wheat varieties with improved grain quality. The EWG on improving wheat quality for processing and health will build on existing basic and applied knowledge and expertise, while capitalizing on outputs of other international initiatives, wheat organizations and other EWGs.

Description of the EWG aims

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 oxydase), 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 fibre, 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.

Expected deliverables/outputs of the EWG

We expect the following deliverables/outputs of this EWG:

1. High yield potential and sustainable quality while withstanding climate change effects.
2. High milling efficiency in producing functional and safe products.
3. Meeting demands of food industries and consumers.
4. Improved germplasm for human health and special health-related and safety requirements.
5. Unified nomenclature of alleles related to wheat quality.
6. Unified methods to analyze substances related to wheat quality.
7. Selecting and sharing standard sets representing quality related alleles.

Timeline of Activities

1. Organizing 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).

Alignment with the Wheat Initiative objectives

This EWG aligns with the Core Theme 4 of the Strategic Research Agenda: Improve quality and safety. In this EWG there is a strong requirement for a collective effort in sharing resources and expertise behind Wheat Quality (in a broad sense), which aligns with the objective of the Wheat Initiative.

Potential links with other Wheat Initiative activities

Durum EWG, International Wheat Genome Sequencing Consortium EWG, Wheat breeding methods and Strategies EWG, WIS EWG, AgMIP Wheat -crop model improvement EWG, Global Wheat Germplasm Conservation and Use Community EWG, IWYP, others.

Supporting countries/institutes

CIMMYT Mexico/China, INRA (France), JIRCAS, NARO (Japan), HAS (Hungary), Rothamsted Research (UK), University of Saskatchewan (CA)

Potential participating countries[1]

Argentina, Australia, China, France, Germany, Hungary, Italy, Japan, Mexico, Sweden, UK, Turkey, India, Canada, Uruguay

Resources (budget requirement, potential funders, etc.)

European Commission - H2020 programs, National programs, CIMMYT, ICARDA, Breeding companies, Food Industry

[1] Not limited to current members of the Wheat Initiative

Planned duration of EWG (in years)
Four years The first two years for establishing a basis for collaboration among members to obtain funds. The last two years for further collaboration to generate new knowledge and to select germplasm with high quality grain.
Other comments
Date of submission to the International Scientific Coordinator