Modern Wheat Breeding – putting Quality on the Map

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History of wheat quality

- The origins of wheat lie 10000 years ago in the fertile crescent -a crescent spanning Israel, Lebanon, Syria & Iraq.
- Early wheats were derived from wild grasses and were diploid or tetraploid.
- The first significant evolution in terms of breadmaking was the hybridization of the tetraploid, Emmer wheat, with a wild grass species, *Aegilops squarrosa* to form the commonly grown hexaploid bread wheats of today.
- The extra 7 chromosomes donated by the grass species contained 2 or 3 additional genes crucial for modern breadmaking -the glutenin genes.
- Further significant progress in wheat quality in the UK did not occur until the 20th century, when Sir Roland Biffen crossed Browick, an English landrace, with a Canadian quality spring wheat, Red Fife, to produce Yeoman, the first English variety with breadmaking quality-
- Further landmark crosses throughout the 20th century via basic plant breeding gave rise to the modem wheat quality gene pool, producing key varieties such as Holdfast - 1935; Widgeon - 1964; Avalon - 1980; Hereward - 1991.
- One of the key advances in the late 20th century was the ability to identify and characterize the glutenin proteins which impart elasticity to the dough, paving the way for systematic advance in wheat quality-
- Breeders have used this information to obtain new balances of high molecular weight (HMW) protein sub-units better suited to either bread or biscuit-making quality.

Modern wheat breeding

- Modem wheat breeding still has its basis in a system developed by Sir Roland Biffen -the pedigree method.

- This involves making a series of crosses to generate genetic variation and selecting down from a population of 2-3 million plants over 8-10 years to one or two genetically uniform novel varieties.

- A number of modem improvements on the system are also utilized, including single seed descent and double haploids which, by growing early generations in growth chambers, achieves several generations per year, enabling the plant breeder to produce finished varieties several years earlier.

- A series of field and quality tests are carried out on these successive generations to select for characters such as yield, disease resistance and quality.

Conventional quality testing

- Quality testing in plant breeding is often limited by tile availability of seed and has traditionally been focused on protein quality and quantity.

- In early generations, tests include:

- Near Infrared Reflectance (NIR) -measuring protein content & grain hardness

- SDS- sedimentation -predicting protein quality

- Hagberg Falling Number (HFN)

- Electrophoresis -high molecular weight protein analysis

- In later generations, it is essential that tests are utilized that more closely mimic the milling and baking industry requirements:

- Farinograph- measuring water absorption and dough strength

- Extensograph -measuring dough extensibility and elasticity

New approaches to wheat quality

- There is a need as plant breeders to expand our knowledge and understanding of our raw material to be able to focus on specific end uses and seek out new opportunities in the food industry.

- Specifically we need to look more closely at the functionality of starch and the variability of storage proteins.

- Significant advances in technology and methodology now mean we are able to look at an increasing range of quality parameters whilst still only utilizing small volumes of seed:
    - Perten Single Kernel Characterisation System -measures single grains for hardness, moisture, weight and size
    - Rapid Visco Analyser -measures starch pasting profiles and viscosity
    - Mixograph - predicts dough strength on a small amount of flour
- The chemical and physical composition of starch can be manipulated to a fair degree by conventional plant breeding techniques, offering the scope to produce novel varieties with benefits for specific end uses or product improvements.
- Altering starch components can affect characteristics such water absorption, staling and shelf life or gelatinisation behaviour in cooking processes.
- Dough extensibility can now be significantly affected by looking for null-alleles of HMW subunits and combining them in the right genetic background.

Putting wheat quality on the map

- One of the greatest advances in plant breeding now is the use of molecular markers to assist in breeding for wheat quality.
- Molecular markers are small sequences of wheat DNA that can be located to specific regions of the wheat genome -the genetic information determining all aspects of the wheat plant.
- These markers can be linked to specific characteristics, such as HMW protein sub-units, and used to track these desired traits through breeding programs.
- By using molecular markers to track specific quality traits, plant breeders can follow traits through the breeding program, ensure that crucial genes are not lost in the breeding process and be much more precise in targeting specific quality characters.
- Markers can now be used to stack combinations of genes that control quality traits of interest that, due to complex genetic inheritance, would be virtually unachievable through standard breeding methodology. Markers also enable these programs of quality breeding to progress at a significantly faster rate.

- A major challenge and effort over the last few years has been to build up a comprehensive map of the wheat genome, to enable more efficient and precise mapping of specific traits.

- The challenge now is for plant breeders to work in conjunction with end-users to more closely relate specific end-use qualities with effective molecular markers.

- This will enable plant breeders to more precisely determine the output of their breeding programs to produce varieties more suited to specific end-use requirements, and potentially unlocking new opportunities for the baking industry .