AGTEC-Org – AGronomical and TEChnological methods to improve Organic wheat quality

A project of the research network CORE organic

Technological quality of organic wheat in Europe

Summary

The demand for high quality organic bread wheat is increasing. The quality level of organic wheat harvested in EU is mainly dependant on variety, environmental conditions and agronomic practices. In some countries, protein content and composition, influencing technological value, are equivalent to those produced under conventional practices.

Beside agronomical techniques, technological processes can help to maintain a good quality. Pre-treatments before milling such as debranning were found to be efficient in reducing DON contamination.

The project highlighted the necessity to redefine the methods to assess the quality of organic wheat.

Context and challenges of the AGTEC-Org project

During the last two decades, the demand for organic bread cereals has developed fast throughout Europe. The organic bread wheat market has been diversified over time throughout the emergence of different sale channels. Requirements from processors and consumers on quality and safety are getting higher for organic bread wheat. Even though consumption varies between European countries, quality requirements on baking value, nutritional aspects and safety risk are quite common. To respond to the domestic demand for organic bread wheat in Western European countries, wheat's quantity has to be enhanced by new conversions and yield improvement strategies, while quality might be improved by agronomical and technological methods. Nitrogen deficiency and weed infestation are the main limiting factors for wheat grain yield and grain protein content. Moreover, mycotoxin is often considered to impair sanitary quality of grain. **The overall objective of AGTEC-Org was to identify agronomical and technological ways to improve the performance of organic wheat and flour. The findings will contribute to an enhanced baking quality and nutritional value of organic flour, as well as to the prevention of mycotoxin contamination to fulfil consumers' expectations of safe and healthy products.** The project involved 9 research centres or universities from 5 European countries with a total budget of about 1.5 million €. An Agronomical leaflet summarizes the relevant information from the AGTEC-Org project on how three main agronomical techniques affect organic wheat quality: (i) reduced tillage, (ii) organic fertilization, use of cover crop and green manure, and (iii) intercropping with legumes. The present leaflet focuses on technological quality of wheat grains from the different agronomical experiments and on the effects on quality of post-harvest treatments and of different milling systems.

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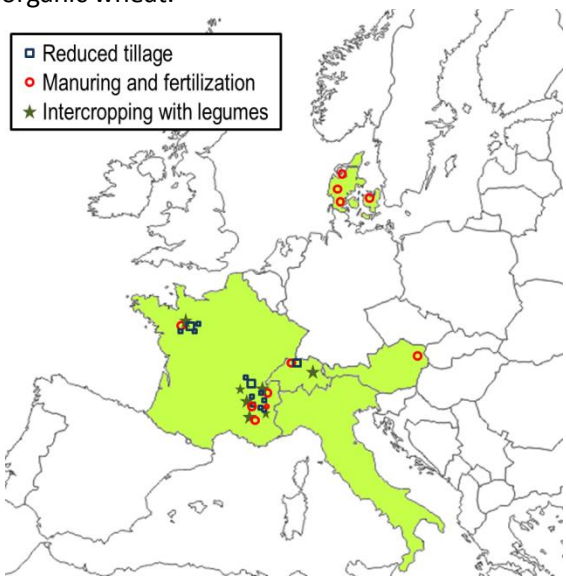
Assessing the effects of agronomical techniques on wheat grain quality

The effect of crop management techniques on wheat grain quality was studied on samples from 11 long-term field experiments and 12 farmers' field trials in four different countries (Austria, Denmark, France and Switzerland). Long-term field experiments considered cumulative effects of tillage and/or nutrition regimes on wheat performance and quality. All together over 150 treatments were tested. To assess the quality of wheat, biochemical and technological tests were performed on grain samples.

Beside this, milling processes and post-harvest treatments (mechanical debranning, ozone treatment with Oxygreen®) were investigated to evaluate their impact on rheological, nutritional and sanitary properties of flours prepared from organic wheat.



Location of the 23 field experiments in Europe

How to assess the technological quality of organic wheat?

The technological quality of the organic wheat produced within the AGTEC-Org project was assessed by means of a number of parameters of common use: ash content, total protein, dry gluten, Gluten Index, Zeleny Index and Falling Number. These parameters provide information about potential wheat baking quality. For selected samples a baking test was performed and results were correlated with quality parameters.

Loaves from the baking test

Ash content of grains and flour

The ash content of grains indicates the amount of bran and hence it represents an important parameter for milling, whereas in flour ash reflects the extraction rate. The lower the ash in grains, the higher the milling yield. Generally, wheat with ash below 2%, or even better below 1.8%, is preferred for milling. The organic wheat from the AGTEC-Org project had ash contents between 1.49 and 2.32 %.

Total protein and dry gluten in grains

Gluten, the viscoelastic component of the dough that allows the rise during leavening, is chemically a protein complex that forms during kneading from two specific protein fractions, namely gliadins and glutenins. These fractions constitute approximately 80% of the protein content. So the higher the protein content in the grain, the higher the gluten in the dough and the better the baking quality. However, protein quantity might be less important than protein quality, because proteins can be of higher or lower quality, as explained in the next paragraph. Protein content is mainly determined by genes (that is, cultivar) and secondly it depends on soil fertility, climatic conditions and agronomic techniques. A total protein content of at least 12% is generally regarded as necessary for an acceptable baking quality in conventional wheat. The organic wheat from the AGTEC-Org project had a total protein content ranging from 6.8 to

15.8 % and it showed an at least acceptable and even good baking quality (determined with a standard high speed dough mixing and short fermentation time method), even when protein content did not reach the above mentioned threshold. Dry gluten is a measure of protein fractions essential for baking and in the AGTEC-Org organic wheat it ranged from 1.6 to 14.0 %.

Gluten Index and Zeleny Index as a measure of gluten strength and overall baking quality

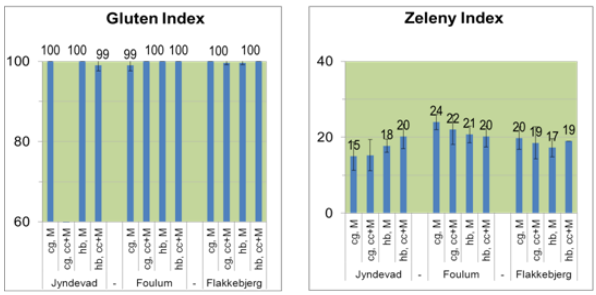
Protein quality is very important: a high protein quality can compensate for a low or medium quantity and specific qualities are required for specific products such as bread, biscuits, cakes, etc.

Gluten Index is a rheological parameter evaluating gluten strength. It is determined on gluten extracted from dough after starch has been washed. The Gluten Index ranges from 0 to 100. Gluten is thus classified as weak (0-25), sufficient (26-45), medium (46-65), strong (66-85) or very strong (> 85). Nearly all the AGTEC-Org samples had very strong gluten.

Glutomatic apparatus for gluten extraction

Zeleny Index is a chemical parameter used in breeding and in rapid analysis to predict the overall baking quality of wheat. It is determined on the ground kernel or on the flour and it ranges from 0 to 80. Wheat having a Zeleny Index below 20 is generally regarded as unsuitable for baking. The organic wheat from the AGTEC-Org project had a Zeleny Index ranging from 11 to 63, yet even those with values below 20 showed an at least acceptable and often good baking quality.

The Zeleny Index and the Gluten Index are generally expected to be in agreement for the same wheat sample, whereas in the case of the AGTEC-Org samples this didn't always happen. The Zeleny Index could better discriminate between samples. As regards the correlation between quality indexes and bread volume, the Zeleny Index gave a better correlation than the Gluten Index, even if it was a weak one. Since these parameters were developed as quality indexes for conventional wheat, their ability to evaluate organic wheat quality should be further investigated.



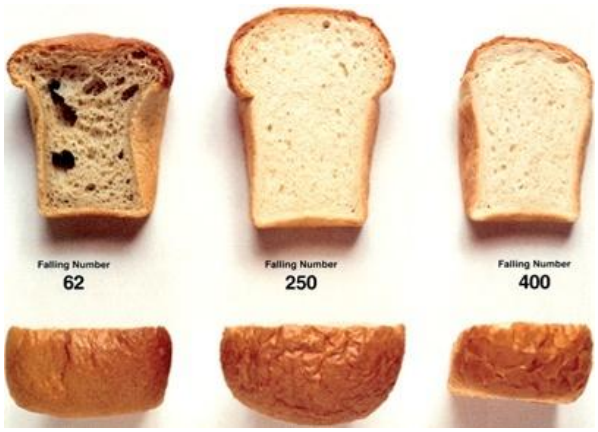
Gluten Index and Zeleny Index of wheat grains from four agronomic treatments in three Danish sites

Falling Number

The Falling Number indicates the activity of the amylolytic enzymes in the wheat grains, which are related to leavening efficiency. The Falling Number ranges from 62 to over 400 sec and depends on the climatic conditions during grain ripening and storage.

Falling Number apparatus

A Falling Number around 250 is considered to be ideal for baking. Values below 200 indicate sprouting and excessive amylolytic activity, values above 300 indicate insufficient activity. Flours with too high a Falling Number can be corrected by adding malt. The Falling Numbers of the AGTEC-Org wheat grains ranged from 161 to 543, mostly above 250.



Crumb of breads made of flours with different Falling Numbers

Baking test

Some grain samples were milled to standard flours and baked according to a standard test to produce pan bread. Loaf volumes were measured and the loaf shape, crust colour, crumb appearance and elasticity were evaluated. The organic flours from the AGTEC-Org project gave at least acceptable and often very good bread compared with commercial conventional flour.

Variability of organic wheat quality in EU

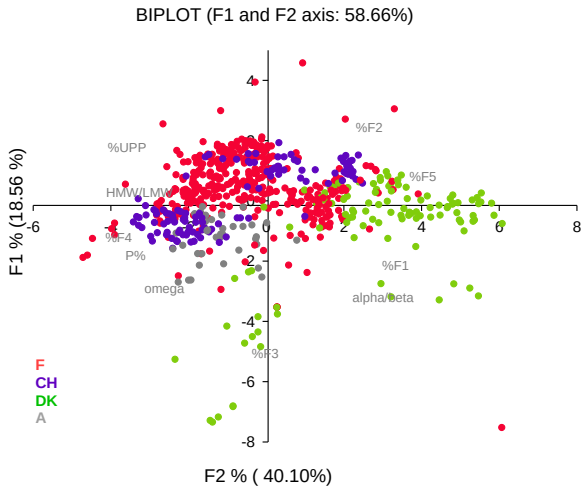
In addition to the common analytical methods previously described, chromatographic techniques (size exclusion and reverse phase) can be used. These techniques identify four main classes of wheat proteins, namely albumins, globulins, gliadins, and glutenins. The last two are the most important from a technological point of view and can be also classified into polymers (glutenins) or monomers (gliadins) based on their aggregating properties. The polymeric proteins are critical for wheat flour processing properties. Their quantity and size distribution as measured by chromatographic techniques, especially the Unextractable Polymeric Protein content (UPP), have been shown to be important indicators for baking quality.

In the AGTEC-Org Project, total protein content and the proportion of the different protein classes extracted from whole wheat grains were determined by the above mentioned chromatographic techniques on 12 different cultivars with 626 grain samples in total. Great variations in protein content and composition were encountered depending on sites, genotypes and agronomical treatments.

First, when considering sites, Danish samples exhibited the lowest protein content followed by French, Swiss and Austrian samples. However, cultivar has to be taken into account when considering this result. The Danish cvs. Opus and Tommi showed the lowest values and the Danish cv. Vinjett showed the highest among all cultivars in the project. Cultivar Vinjett exhibited also an unexpected protein composition with a very low UPP content, a high proportion of soluble polymeric proteins (F1 and F2) and a high gliadin content (F4). Cultivars Tommi and Opus were characterized by an unusually high proportion of albumins and globulins (*i.e.* F5 or non gluten proteins) indicating poor technological properties (negatively correlated with bread volume). Swiss (cvs. Runal, Lona), Austrian (cv. Capo) or French (cvs. Renan, Camp Remy) wheats were characterized by higher protein content and higher UPP content, close to those found for European bread wheat grown under conventional systems. This finding is consistent with the good technological properties of these wheats, generally considered as high quality wheats (cv. Runal and Renan in particular).

Finally, in some cases, low protein contents may be counterbalanced by an unexpected high polymeric protein proportion explaining a rather good baking quality.

Correlations were confirmed between biochemical data and technological parameters. First, the gliadin fraction was tightly and positively linked with Total Protein and Dry Gluten contents and with Zeleny Index. On the contrary, the albumin/globulin fraction was negatively correlated with these three parameters. A negative correlation was also found between F5 and the bread volume. No clear correlation was found between Gluten Index and other biochemical data.



Principal component analysis (PCA) of wheats and design variables (% of fractions F1 to F5, omega-, alpha/beta-, gamma-gliadins, % of UPP, HMW/LMW and Glia/Glu ratios, % of total proteins -P%-). Correlation loading plot for PC1 and PC2. F1 to F5 is referring to protein classes separated by size exclusion chromatography. F1 and F2: glutenin polymers, F3: omega gliadins and high molecular weight albumins, F4: gliadins, F5: albumins/globulins. HMW/LMW=High Molecular Weight to Low Molecular Weight glutenin ratio.

Impact of milling techniques and post harvest treatments on flour composition and bread quality

The quality of organic cereal products depends not only on the cropping system they come from, but also on the way they are processed, especially on the milling techniques utilised to prepare flour. A comparison between stone milling and roller milling was undertaken in the AGTEC-Org project to compare the nutritional, sanitary and organoleptic properties of flours obtained with these two milling systems at different milling yields (75, 80 and 85 %). In fact, flour composition and characteristics are strongly affected by the milling technique as well as by the milling yield.

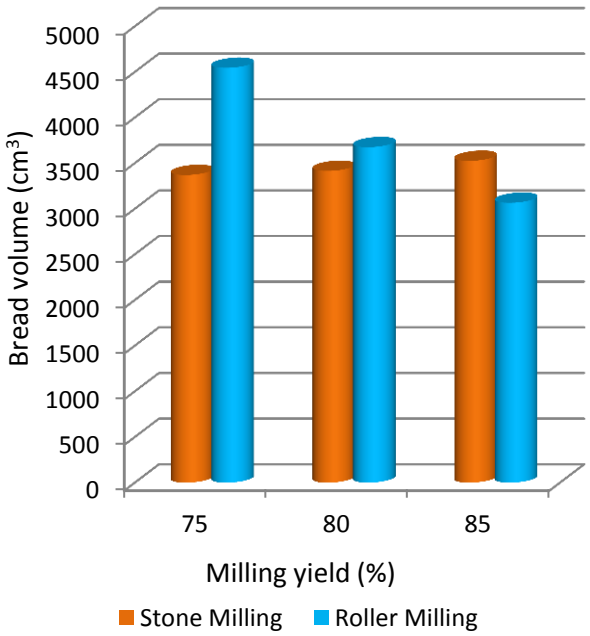
Experimental stone mill

Flour manufactured by means of stone milling exhibited a higher content of the aleurone layer (beneficial for nutritional quality), as measured by the ash content or by the phytate content, but also a higher DON content (detrimental for safety), compared to roller milling. Moreover, in the case of the stone milling process, the bread volume was lower (detrimental for sensorial properties) and this could not be modulated by adjusting the milling yield. Interestingly, this could turn into an advantage when making whole meal bread, since the bread volume was little affected by the different milling yields of stone milled flours.

Contrary to stone milling, milling yield had a great influence on the characteristics of flours obtained by means of roller milling. Thus with a low milling yield after roller milling (<75%) a higher bread volume was obtained.

Experimental roller mill

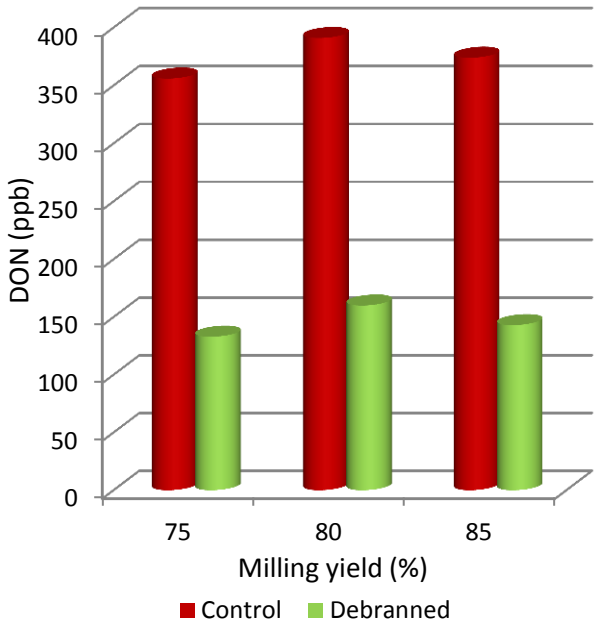
Increasing the milling yield by means of roller milling, with the aim to improve the overall nutritional quality of the flour, resulted in a very detrimental effect on both safety and bread making quality, even if protein content increased.



Comparison of milling system and milling yield on bread volume

Grain pre-treatments before milling (mechanical debranning or ozone treatment with Oxygreen®) did not modify grain milling behaviour. Large differences between flour characteristics according to the two milling systems remained. However, the pre-treatments appeared very efficient at lowering the flour DON content,

especially with the stone milling process. As far as safety issues within the organic chain are concerned, the introduction of grain pre-treatments would allow the production of safer organic flours even at high milling yields.



Effect of mechanical debranning (7%) before stone milling on flour DON content.

Selected publications

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David C, Celette F, Abecassis J, Carcea M, Friedel J, Corre-Hellou G, Hiltbrunner J, Messmer M, Peigné J, Samson MF, Schweinzer A, Thomsen IK and Thommen A (2011) New challenges to improve organic bread wheat production in Europe. In: 3rd ISOFAR Scientific Conference in the frame of the 17th IFOAM Organic World Congress, Gyeonggi Paldang, South Korea, September 26-October 5 2011. http://orgprints.org/19483/

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Thomsen IK, Samson MF, Carcea M, Narducci V. (2011). The influence of long-term inputs of catch crops and cereal straw on yield, protein composition and technological quality of a spring and a winter wheat. International Journal of Food Science and Technology. 46: 216–220. http://orgprints.org/18803/

Acknowledgements

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