WHEAT DIGESTIBILITY

Wheat Variety and Sourdough Product Analysis for Anti-Nutrient Levels Related to Digestibility

Introduction

The Minnesota Wheat Research and Promotion Council (MWRPC), in partnership with the University of Minnesota, the Agricultural Utilization Research Institute and Back When Foods, conducted a study investigating options to reduce wheat digestibility concerns of consumers by identifying specific varieties of wheat with lower levels of naturally occurring anti-nutrients. Fermentation was also evaluated as a processing technique to further reduce the FODMAP and ATI anti-nutrients. Wheat digestibility concerns include non-celiac gluten sensitivity and irritable bowel syndrome (IBS), which some research suggests may be exacerbated by anti-nutrients such as fermentable sugars known as FODMAPs (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) and ATI (amylase trypsin inhibitor) proteins. The process of developing low reactive wheat food products is a combination of selecting the right wheat variety and utilizing alternative processing, such as sourdough fermentation, such that FODMAPs and ATIs are substantially reduced in finished products.

Wheat Materials for FODMAP Evaluation

Material	No. lines
Heritage wheats	46
Modern wheats(>1970):	142
Durum:	5
Einkorn (A genome):	10
Emmer: (AB)	11
Synthetic hexaploids (ABD):	16
Total:	**230**

Lots of variation observed for heading date, height, yield

Wheat Materials Evaluated

University of Minnesota research for this project aimed to characterize the FODMAPs and ATI in 220 (germinated) out of 230 ancient, heritage and modern spring wheat varieties curated by the University of Minnesota wheat breeding program. The panel contains varieties introduced into the region in the 1800's and derived from breeding and selection dating back to 1895. These varieties were grown at University of Minnesota field sites in Crookston and St. Paul, MN in 2019. After harvesting, whole grain wheat samples were analyzed for the amount of FODMAPs and ATI. DNA was extracted from all the varieties and they were genotyped using genotyping-by-sequencing. The resulting DNA markers were used to find associations with genes influencing FODMAP and ATI content.

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Research Summary

The results from the wheat samples showed significant variation in FODMAP and ATI levels across a diverse panel of wheat varieties, including modern wheat germplasm. FODMAPs and ATI levels ranged from 0.4 to 1.2 grams per 100 grams and 1.8 to 3.9 grams per 100 grams, respectively. The ancient Einkorn and Emmer wheats were consistently low in FODMAPs, and Einkorns were also low in ATI. Results from genetic mapping did not show any genomic region responsible for a large portion of the genetic variation for these traits. It is many genes of minor effect that are explaining most of the variations for ATIs and FODMAPs. Both traits, however, should be amenable to selection using conventional breeding methods or genomic prediction.

This research also looked into the effects of fermentation on the levels of FODMAPS and ATI as shown in the bar charts. This involved the preparation of sourdough (Type 1) at different fermentation times (4 hours and 12 hours).

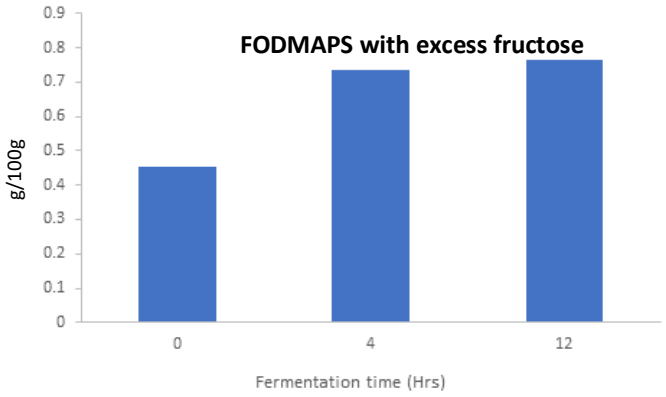
There was a decrease in the fructan contents (a major component of FODMAPS) as fermentation proceeded. Fructans with a degree of polymerization (DP) less than 10, also known as fructooligosaccharides, decreased by about 70% (0.18 to 0.06 grams per 100 grams) after 12 hours of fermentation. Fructans with DP > 10, also known as inulin and raffinose, decreased by 37% and 69% respectively after 12 hours of fermentation. Fermentation was found to reduce some of the components that make up FODMAPs, but not the polyols (mannitol), in the fermented doughs. Mannitol increased from 0.1 and 0.5 per 100 grams at 4 hours and 0.1 and 0.7 grams per 100 grams at 12 hours fermentation. These results represented an increase of 440% and 552%, respectively. Increases in the polyols were expected since the yeast converted the fermentable sugars present in the wheat samples into alcohols. These alcohols would be lost when the doughs are baked into bread or cookies.

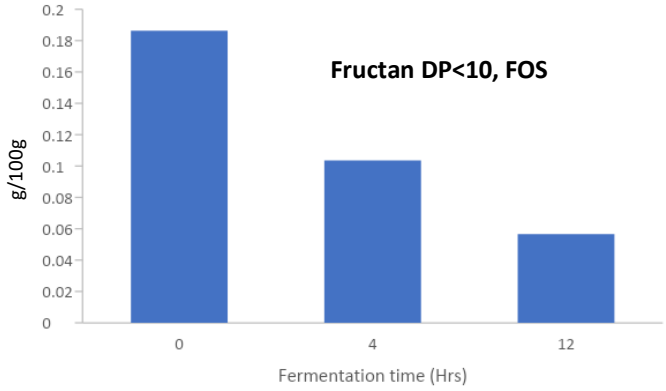
The increase in the polyols resulted in an increase in the overall FODMAP contents of the wheat samples during fermentation. At 4 hours of fermentation, the FODMAP content of the wheat samples increased from 0.45 to 0.74 grams per 100 grams representing a 63% increase in the FODMAPs. An additional increase of about 6.5% was observed when fermentation proceeded from 4 to 12 hours. It is important to note that any decrease in the polyol content during baking will correlate to significant reductions in the levels of FODMAPs in the final product.

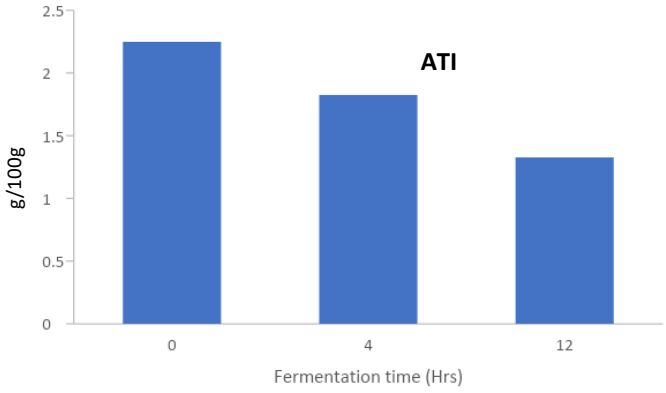
Fermentation also reduced the levels of ATI in the wheat samples. On average, ATI levels reduced from 2.25 to 1.83 grams per 100 grams at 4 hours and 1.33 grams per 100 grams at 12 hours of fermentation, representing reductions of 18% and 41%, respectively.

In conclusion, the variations in the levels of FODMAPs and ATI in the wheat varieties screened may allow for the selective breeding of wheat for lower levels of FODMAPs and ATI. Because both FODMAP and ATI levels appear to be under complex genetic control, selective breeding for these traits will be more difficult. But, new approaches involving DNA sequencing and genomic prediction will be used to enhance breeding efforts to reduce FODMAP and ATI levels. Fermentation was effective in reducing the levels of ATI and Fructans in the fermented wheat doughs.

To learn more about this research and follow its progress, visit: www.auri.org/agri.







Next Steps

Using the wheat varieties identified in Phase I, Phase II research is also being proposed to build upon the current research results to further develop wheat varieties that not only have improved digestibility but also have higher amylose and resistant starch (fiber) for a lower glycemic index and improved gut health (microbiome).

Financial support for this project is provided by an Agricultural Growth, Research, & Innovation Crop Research Grant (AGRI) from the Minnesota Department of Agriculture. The AGRI program awards grants, scholarships, and cost shares to advance Minnesota's agricultural and renewable energy industries. For more information about the AGRI program, visit www.mda.state.mn.us/ grants/agri.

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