

Introduction

- Innovations in traditional foods (e.g., bread) are necessary to decrease cost, increase sustainability, and produce safer and healthier options without changing the product's original characteristics¹.
- Bread wheat (*Triticum aestivum*, genome AABBDD) originated from the natural hybridization between domesticated emmer (tetraploid, genome AABB) and wild goat grass (genome DD)².
- Bread wheat's genetic base is narrow, and domestication decreased its genetic variation even more³.
- Synthetic wheats, which are created by crossing a tetraploid wheat, e.g., durum wheat, with wild goat grass serve as a genetic pool to bring quality traits that may have been lost during bread wheat domestication⁴.
- Examples of traits that can be recovered from synthetic wheats are resistance to disease and environmental stress as well as grain quality⁵.

Synthetic wheats can offer genetic diversity, helping to tackle challenges in the field and broaden end-use options^{4,5}.

Change of ingredients (e.g., wheat flour) can affect dough's strength, thus the final product's quality.

Rheological tests, such as Mixograph and shear rheology, are useful tools to measure dough strength.

Objective

To investigate whether mixograph and shear rheology can differentiate different synthetic wheat flours based on their dough's physical properties.

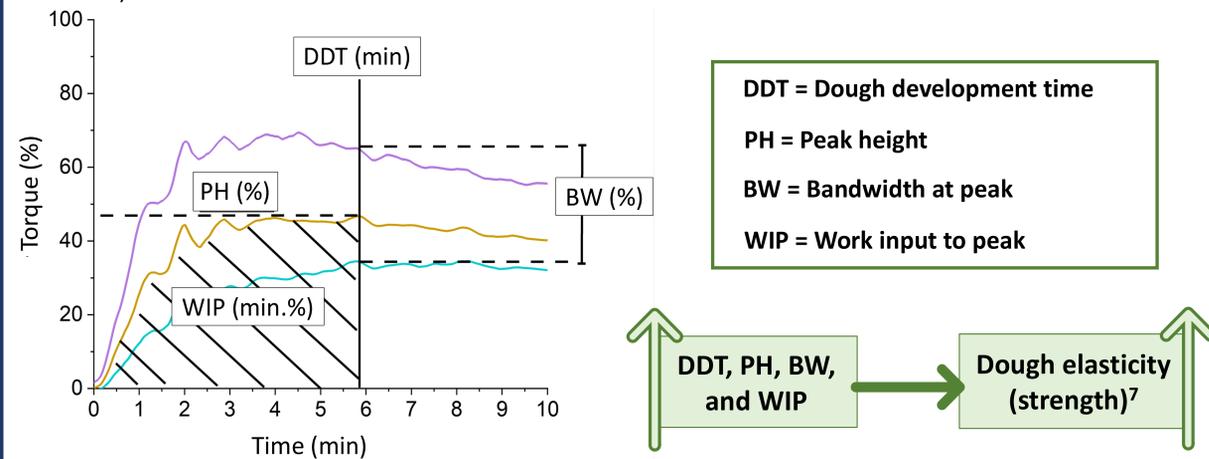
Materials and Methods

Materials

- Eleven (11) synthetic wheat flours from a breeding program and a white wheat flour (CWRS, control).

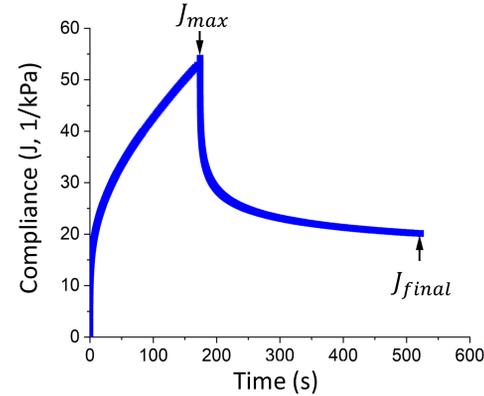
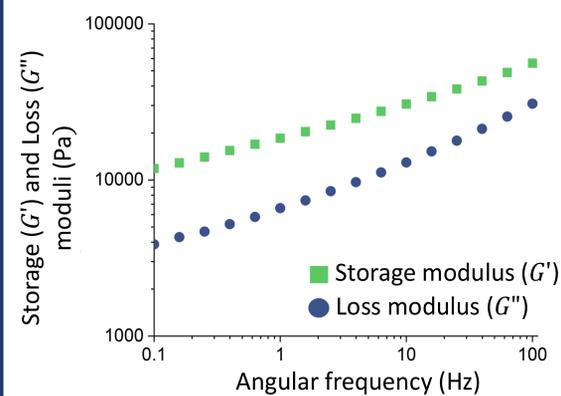
Mixing

- Mixing tests were performed using a 2-g computerized Mixograph (National Manufacturing, Lincoln, NB, Canada) at a constant water content of 58%.



Shear rheology

- Doughs were prepared by mixing flours with water (58% dry basis) until their DDT.
- Shear rheology tests were conducted using a rotational rheometer⁸.
- Frequency sweep test
 - Constant shear strain of 0.02%
 - Angular frequency from 0.1 to 100 Hz
- Creep-recovery test
 - Constant shear stress of 250 Pa for 180 s
 - Constant shear stress of 0 Pa for 360 s



- From G' and G'' at 10 Hz:

$$\tan \delta = \frac{G''}{G'}$$

Loss tangent

G' , Recovery

$\tan \delta, G''$

Dough elasticity (strength)

- From J_{max} and J_{final} :

$$\text{Recovery}(\%) = \left(\frac{J_{max} - J_{final}}{J_{max}} \right) \times 100$$

Statistical analysis

- Tukey test was performed using OriginPro software (Version 2025, OriginLab Corporation, Northampton, MA, USA).

Results and Discussion

Table 1. Mixing parameters obtained from Mixograph tests.

Sample	DDT (min)	PH (%)	BW (%)	WIP (min.%)
Control	8.2±0.5 ^a	35±0 ^b	29±0 ^c	220±20 ^a
1	4.0±0.5 ^{cd}	51±4 ^{ab}	43±4 ^{ab}	138±26 ^{ab}
2	6.5±0.5 ^{abc}	50±2 ^{ab}	39±1 ^{abc}	156±4 ^{ab}
3	7.0±0.8 ^{ab}	45±2 ^{ab}	38±3 ^{abc}	217±39 ^a
4	5.3±0.9 ^{bcd}	59±15 ^a	46±3 ^a	173±33 ^{ab}
5	5.0±0.5 ^{bcd}	56±2 ^{ab}	48±1 ^a	169±22 ^{ab}
6	3.6±0.3 ^d	48±0 ^{ab}	39±1 ^{abc}	114±16 ^{ab}
7	3.9±0.4 ^{cd}	51±3 ^{ab}	38±1 ^{abc}	130±28 ^{ab}
8	3.2±0.5 ^d	50±4 ^{ab}	39±6 ^{abc}	111±21 ^{ab}
9	3.6±0.3 ^d	40±4 ^b	29±5 ^c	98±6 ^b
10	5.2±1.6 ^{bcd}	45±4 ^{ab}	37±1 ^{abc}	171±75 ^{ab}
11	5.6±0.4 ^{abcd}	48±2 ^{ab}	34±4 ^{bc}	198±23 ^{ab}

Table 2. Parameters from frequency sweep tests.

Sample	G' (10 Hz, kPa)	G'' (10 Hz, kPa)
Control	65.8±2.6 ^a	21.0±0.4 ^a
1	29.1±2.6 ^{de}	12.3±1.0 ^{cd}
2	47.8±3.9 ^b	17.6±1.6 ^b
3	39.3±0.9 ^c	14.7±0.6 ^{bcd}
4	47.8±1.5 ^b	17.5±0.6 ^b
5	36.1±2.0 ^{cd}	14.4±0.5 ^{bcd}
6	26.0±3.8 ^e	11.7±1.7 ^d
7	32.2±1.0 ^{cde}	15.2±0.6 ^{bc}
8	36.9±0.6 ^{de}	17.2±0.3 ^b
9	27.0±2.1 ^e	12.2±1.0 ^{cd}
10	38.0±5.2 ^c	16.5±2.0 ^b
11	38.2±3.0 ^c	17.2±1.2 ^b

Data represents mean ± SD, $n \geq 2$. Means with different letters on the same column are significantly ($p < 0.05$) different. DDT = Dough development time; PH = Peak height; BW = Bandwidth at peak; WIP = Work input to peak.

Data represents mean ± SD, $n \geq 3$. Means with different letters on the same column are significantly ($p < 0.05$) different. G' = Storage modulus; G'' = Loss modulus.

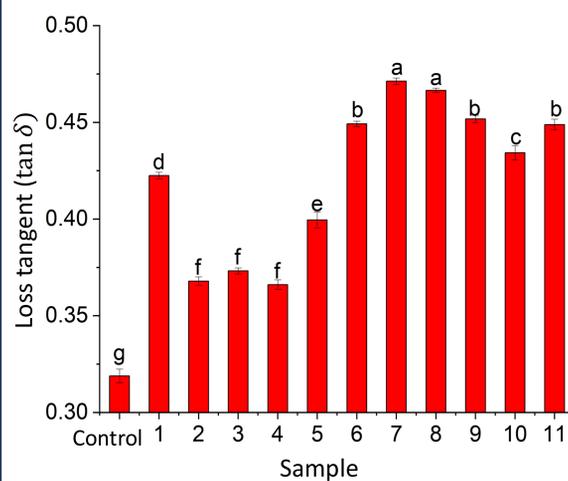


Figure 1. Loss tangent of doughs. Error bars represent SE ($n \geq 3$). Means with different letters are significantly ($p < 0.05$) different.

- Samples 7 and 8 possessed the highest $\tan \delta$ values, thus weaker, or less elastic, doughs (Figure 1).

- Among the synthetic wheat flours, samples 2, 3, and 4 had the lowest $\tan \delta$ values, indicating stronger doughs (Figure 1).

- When tested at a higher shear stress value via creep-recovery tests, the control had the highest recovery, forming the strongest dough. Sample 9 had the lowest recovery, forming the weakest dough among all the samples studied (Figure 2).

- Excluding the control, samples 1, 2, 3, and 5 had the highest recovery (>60%) after the shear stress removal, indicating that they formed the strongest doughs among the synthetic wheat flours studied (Figure 2).

- During mixing, the control flour had the highest DDT and WIP among all the samples studied (Table 1).

- From mixing tests, the DDT and BW parameters were the best in differentiating synthetic wheat samples (Table 1).

- Sample 9 had the lowest BW, WIP, PH, and one of the lowest DDT values, indicating that it possessed the lowest resistance to mixing and a weaker dough strength among all samples (Table 1).

- Frequency sweep tests were better at differentiating synthetic wheat samples compared to mixing tests, with control dough possessing the highest G' and G'' values (Table 2).

- Among the synthetic wheats studied, samples 2 and 4 showed the highest G' values, indicating the formation of an elastic and strong dough, whereas sample 9 showed the lowest G' value (Table 2).

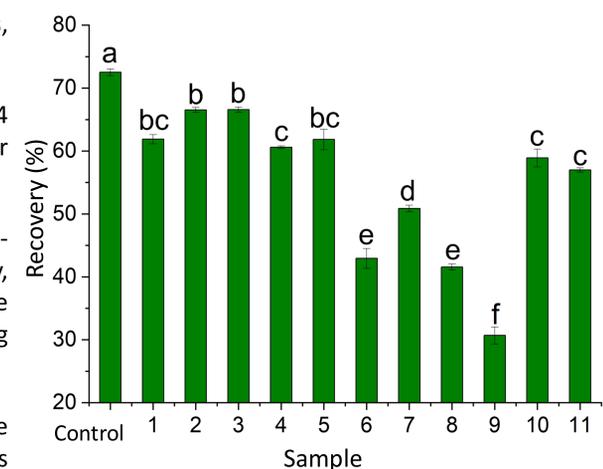


Figure 2. Recovery from creep-recovery tests of doughs. Error bars represent SE ($n \geq 3$). Means with different letters are significantly ($p < 0.05$) different.

Final message

- Mixograph results showed that the eleven synthetic wheat flours varied in mixing strength, with higher variations in DDT and BW parameters compared to PH and WIP.

- Compared to mixing tests, shear rheology tests were better at differentiating synthetic wheat flours based on their respective dough's physical properties.

- Overall, synthetic wheat flours formed weaker doughs than the control. However, some synthetic wheat flours formed stronger doughs than others, indicating potential suitability for breadmaking or other bakery applications.

References



Acknowledgements