

Optimization of Alkaline Pretreatment and Ultrasound-Assisted Extraction of Phenolic Compounds from Rye

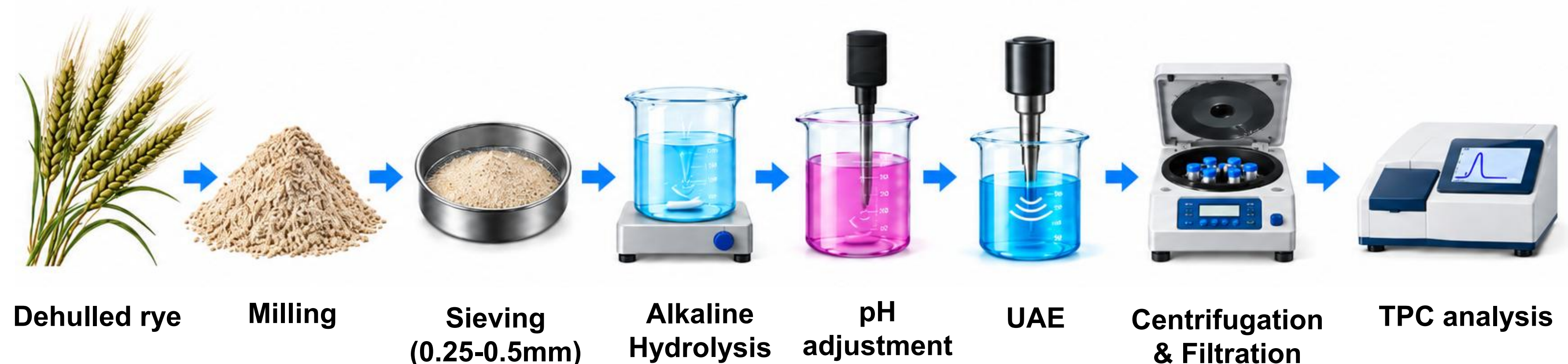
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BACKGROUND & AIM

-  **Rye (*Secale cereale* L.)** is a rich source of phenolic and other bioactive compounds.
-  Most of the phenolics are bound to the cell wall matrix, which limits conventional solvent extraction.
-  Alkaline hydrolysis is highly effective at cleaving chemical linkages and release bound phenolics.
-  Ultrasound-assisted extraction (UAE) may enhance phenolic acid recovery by promoting mass transfer and disrupting the plant matrix through acoustic cavitation.

Aim: Optimize alkaline pretreatment first, then evaluate whether UAE further enhances phenolic recovery from rye

EXPERIMENTAL OVERVIEW



Stage 1: Alkaline hydrolysis optimization

- vary NaOH concentration (2.5 M, 3.75 M, 5 M)
- vary hydrolysis time (30, 40, 60, 90, 120 min)

Stage 2: UAE after alkaline pretreatment

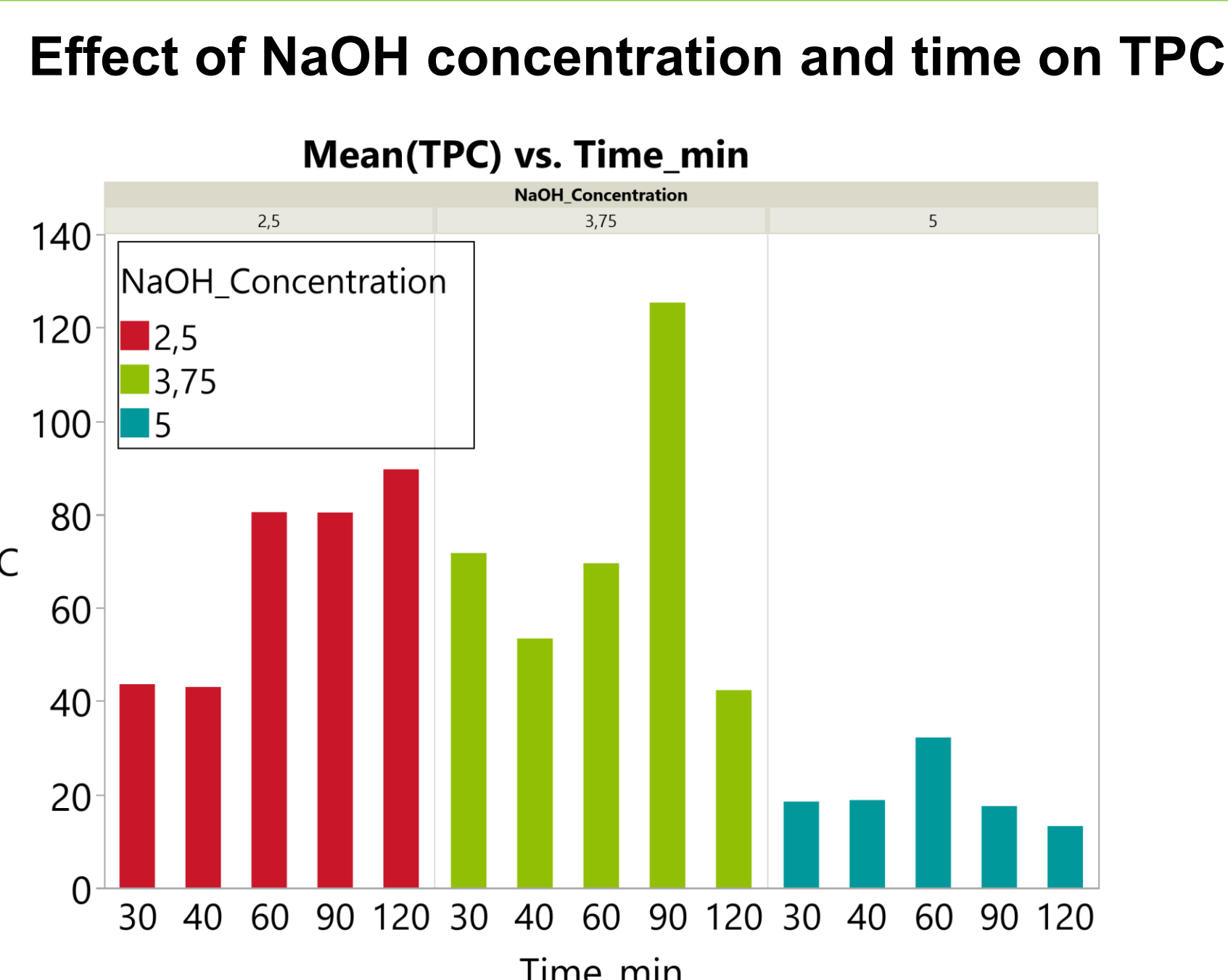
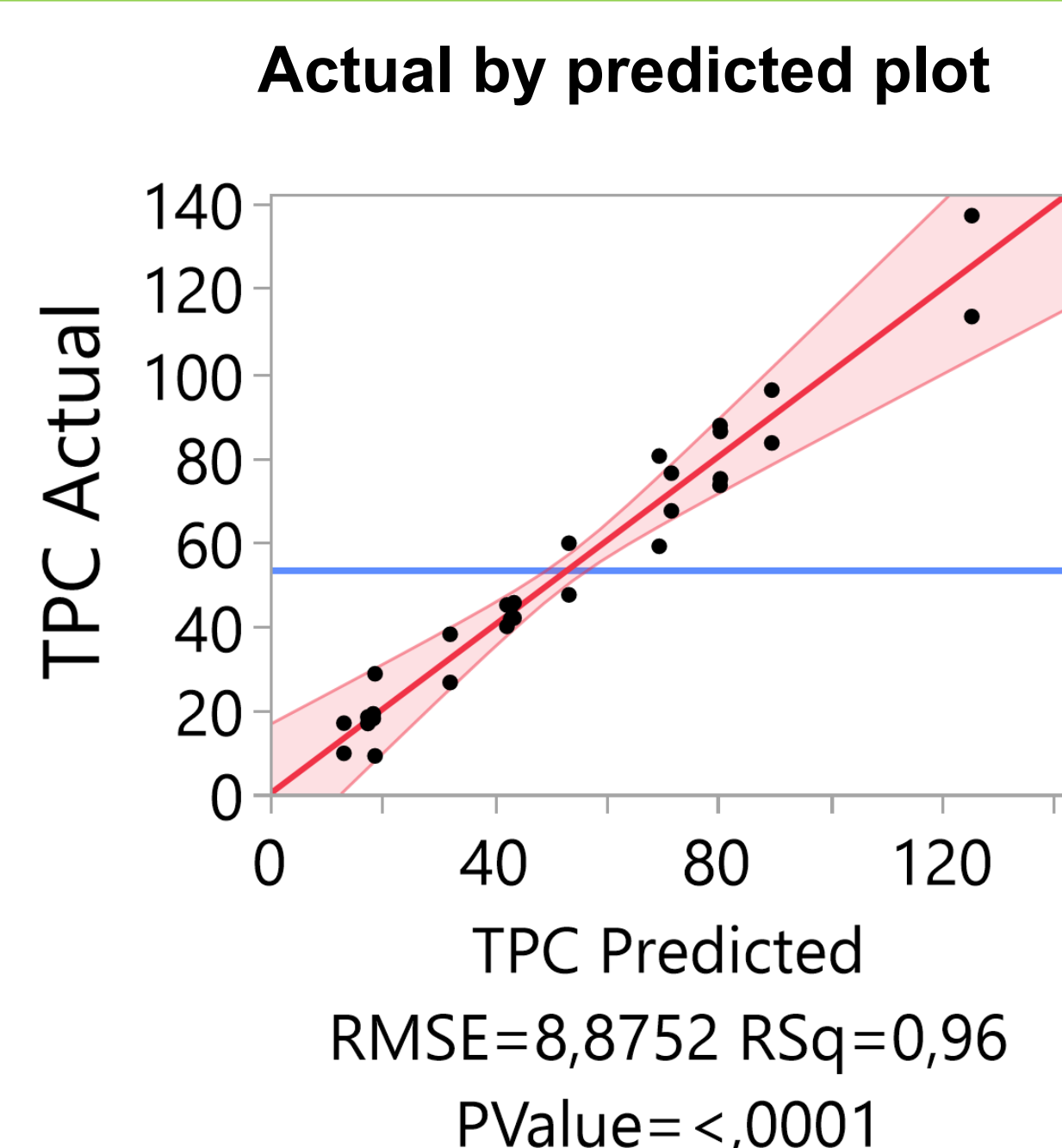
- use the selected alkaline condition
- optimize ultrasound time (10-60 min)
- optimize temperature (30-60 °C)
- optimize amplitude (20-70 %)

Identify the optimized alkaline conditions

Evaluate whether UAE further enhances phenolic acid recovery

STAGE 1: FULL FACTORIAL EXPERIMENTAL DESIGN FOR ALKLAINE HYDROLYSIS

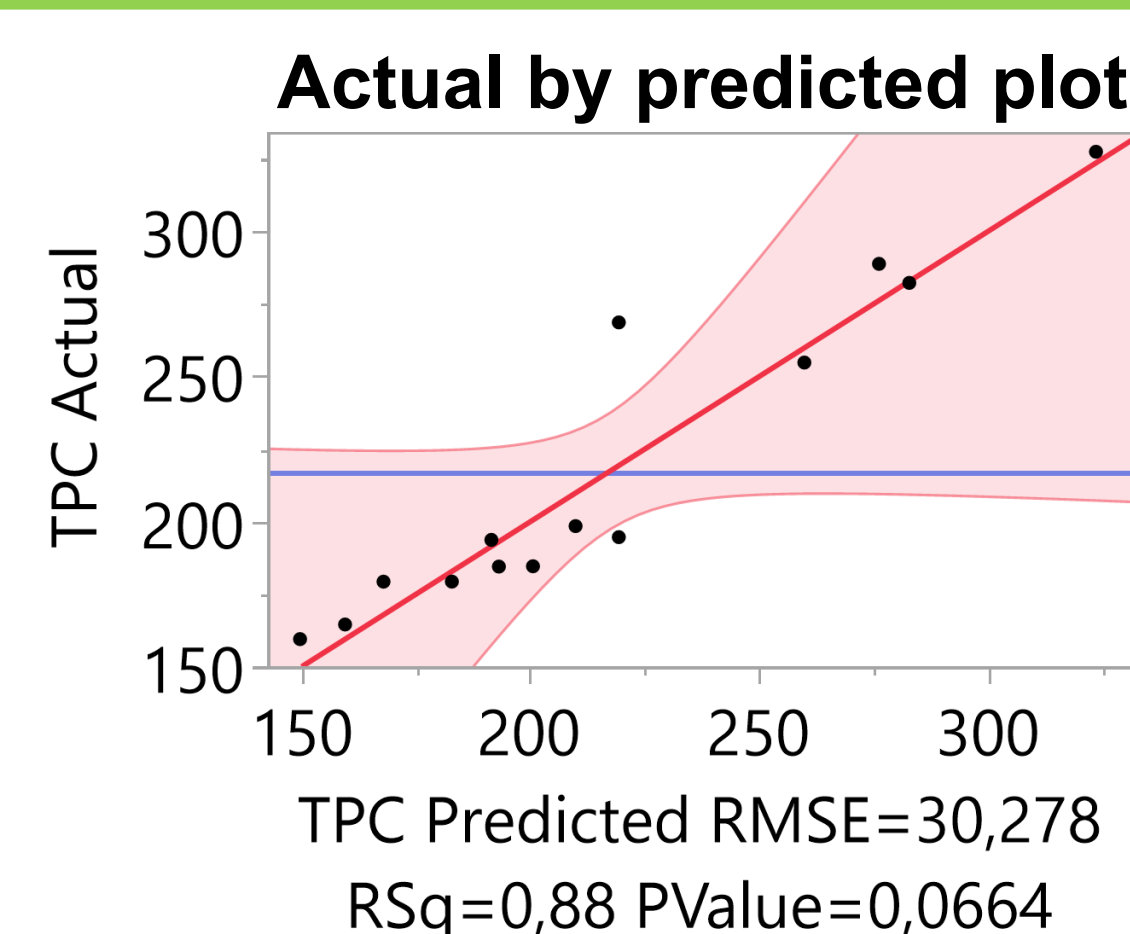
- The model explained **96% of the variation** in total phenolic content (TPC) of rye.
- **NaOH concentration** was the dominant factor.
- **Main finding:**
The highest total phenolic content was obtained at **3.75M NaOH and 90 min.**



Selected alkaline pretreatment

NaOH Concentration: **3.75 M**
Hydrolysis time: **90 min**
Response: **Highest TPC**

STAGE 2: UAE AFTER ALKALINE PRETREATMENT



Effect summary

Source	Logworth	PValue
Temperature_C*Temperature_C	1,782	0,01653
Time_min	1,523	0,02999
Time_min*Time_min	1,140	0,07249
Time_min*Amplitude_Percent	1,082	0,08280
Temperature_C	0,594	0,25481 ^
Amplitude_Percent*Amplitude_Percent	0,378	0,41919
Time_min*Temperature_C	0,282	0,52246
Temperature_C*Amplitude_Percent	0,207	0,62111
Amplitude_Percent	0,204	0,62581 ^



Optimized conditions: Dehulled Rye

Extraction time: **60 min**
Temperature: **45 °C**
Ultrasound amplitude: **70%**

- The model explains about **88%** of variation in TPC of rye.
- **Temperature** was the most influential factor.

CONCLUSION

- Alkaline pretreatment improved phenolic acid recovery.
- UAE further improved extraction after pretreatment.
- The combined method is promising for recovering bio active compounds from rye.

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Co-funded by
the European Union