Evaluation of root firmness and cell wall components in sugarbeet lines for reducing sugar loss during post-harvest piling storage

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Introduction

Roots of sugarbeet (*Beta vulgaris* L. ssp. *vulgaris* Doell.) are easily injured during harvesting or making piles for storage prior to processing in sugar factory, which increases root rot and enhances respiration of root tissue for wound healing and leads to significant sugar loss. Increase root tissue firmness will provide a solution for this issue. In this study, we will evaluate root tissue firmness and cell wall components in 336 sugarbeet genotypes to find out the relationship between root firmness, sugar content, and cell wall pectin compositions before and after roots were cold stored for three months. A genome-wide association study (GWAS) will be conducted to identify genomic regions associated with root firmness and cell wall pectin components to develop markers linked to genes that increase root hardness. This research will identify genetic sources and develop markers for efficiently creating new germplasm with enhanced root hardness.

Materials and Methods

A set of 336 sugarbeet genotypes were selected based on genetic diversity study in Tehseen et al. (2023), and those lines were originated from 50 countries.

After root were cleaned, three roots per genotype were randomly selected to test tissue firmness using a fruit texture analyzer to measure the force (Kg) needed for a probe to penetrate tissue about 0.5 cm (Fig. 1). Each root was tested at four sides with and without skin to represent puncture resistance and pressure resistance, respectively. Three analyzed roots, along with several other roots from the same genotype were ground together to make brei for further testing of dry matter percentage, sugar content, cell wall materials and pectin types.

After root were stored at 5℃ for three months, all above mentioned tests were conducted again in each genotype to compare the change of each trait during cold storage.

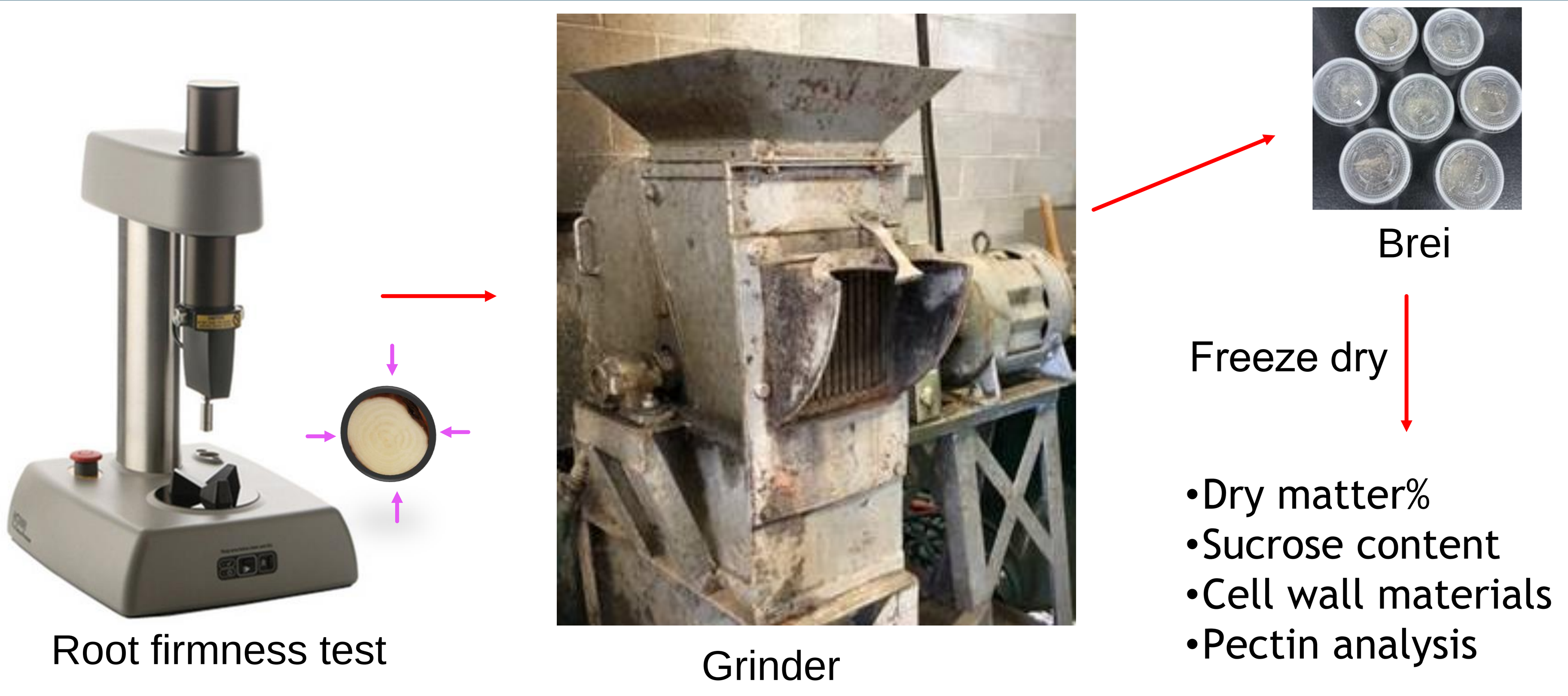


Fig. 1. Diagram to show root firmness and other quality test.

Results

Firmness and dry matter percentage tests within the first month during cold storage

A wide range of root firmness in the set of genotypes were observed for both puncture and pressure resistance (Fig. 2), which indicated the significant variations existed in these germplasm lines. As expected, the two type of firmness are highly correlated (r = 0.84, P < 0.0001) except for a little extra force need for penetrating root skin.

Dry matter percentage in tested genotypes ranged from 9% to 27%, it shows significant positive correlations with tissue firmness (r = 0.52 and 0.49, P < 0.0001, Fig. 3), indicating a higher sucrose concentration likely leads to a stronger root.

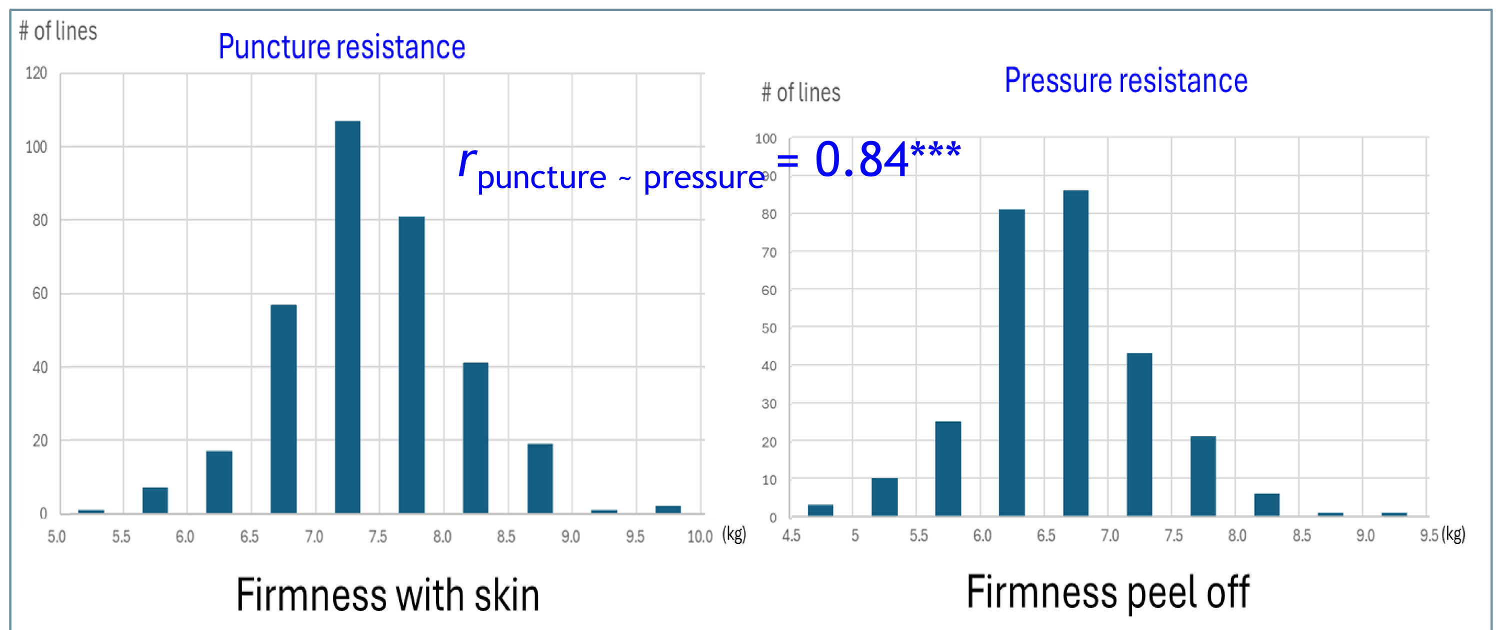
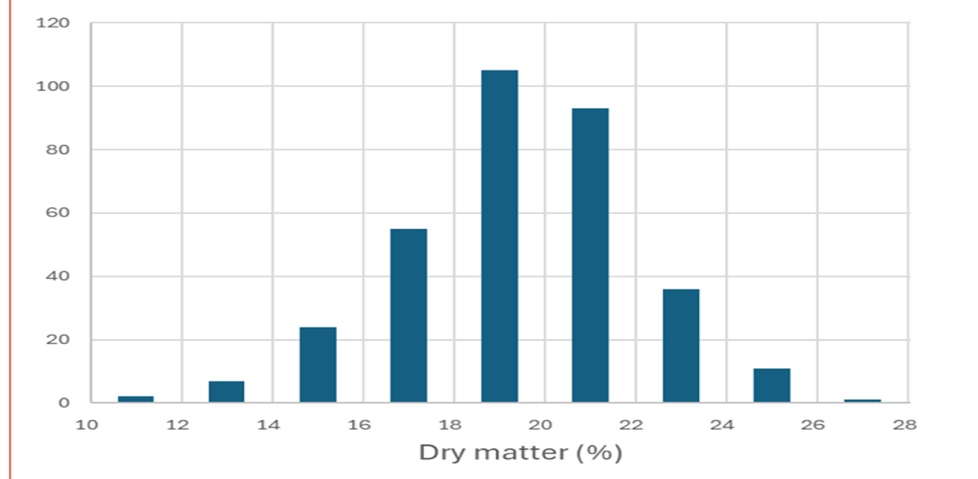
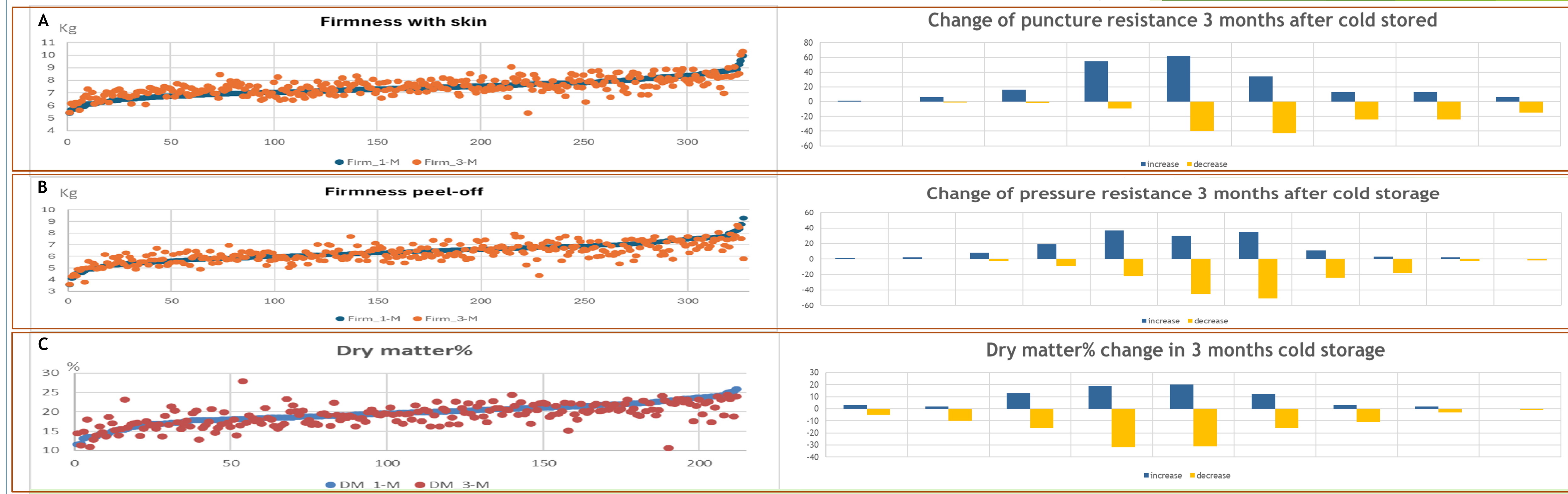


Fig. 2. Distribution of root firmness in 336 sugarbeet genotypes as root cold stored within a month.



dry matter ~ firmness with skin: r = 0.52***
dry matter ~ firmness with peel-off: r = 0.49***
AVG DM% (softer) = 17.1%; AVG DM% (harder) = 21.3%

Fig. 3. Dry matter% in sugarbeet genotypes as root cold stored in a month.



Correlations: Dry_M-1-M ~ Firm_1-M: r = 0.49*** Dry_M-3-M ~ Firm_3-M: r = 0.43***

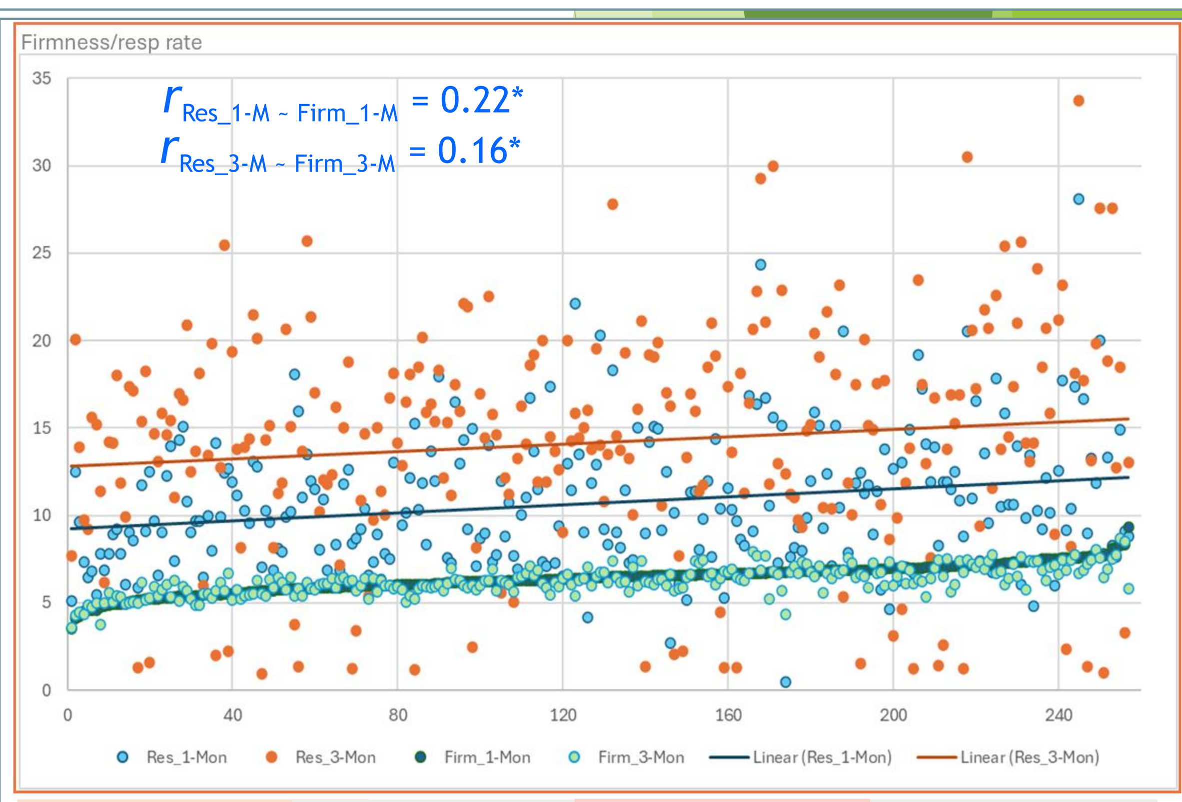
Fig. 4. Change of puncture resistance, pressure resistance and dry matter percentage after sugarbeet root cold stored for three months.

Firmness and dry matter tests after root cold stored for three months

After cold stored for three months, puncture resistance likely increased in the softest roots but significantly decreased in most harder roots (Fig. 4A). Pressure resistance showed the similar trends during cold storage (Fig. 4B). This suggested that softer roots may relatively lose more moisture and less dry matter to make root surface harder, but the harder roots may relatively lose more dry matter to become softer. It is approved that majority of harder root genotypes showed significant decrease of dry matter after cold storage (Fig. 4C). Ongoing tests of sucrose content and cell wall pectin types will provide more information.

Combining analysis of root firmness, dry matter content and respirations rate during root cold storage

After combining data from respiration test during cold storage (Bostan et al., 2025, Poster #12), softer roots tend to have lower respiration rate than the harder ones (Fig. 5). Respiration rates showed loosely but significant correlations with root firmness during root cold storage. This confirms the harder roots tend to have a higher respiration rate and may lead to lose more sucrose during post-harvest root storage.



$Res\_1\text{-}M_{softer}$ = 9.4	$Res\_3\text{-}M_{softer}$ = 13.7	$DM\_1\text{-}M_{softer}$ = 17.1%	$DM\_3\text{-}M_{softer}$ = 16.1
$Res\_1\text{-}M_{firmer}$ = 12.1	$Res\_3\text{-}M_{firmer}$ = 17.1	$DM\_1\text{-}M_{firmer}$ = 21.3%	$DM\_3\text{-}M_{firmer}$ = 20.5

Fig. 5. Combining comparison of root firmness and respiration rate for root cold stored 1 and 3 months.

Conclusions

- Roots with higher sucrose concentration tend to have a higher respiration rate during cold storage
- Genotypes with higher dry matter percentage (higher sucrose content) will lead to harder roots, and such genotypes with lower respiration rate during cold storage will be useful germplasm for breeding to reduce post-harvest sugar loss.
- Cell wall material analysis is ongoing, which will help understanding role of pectin types to tissue firmness.

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References

Tehseen et al. (2023). Potential of publicly available Beta vulgaris germplasm for sustainable sugarbeet improvement indicated by combining analysis of genetic diversity and historic resistance evaluation. Crop Science, 63, 2255–2273. https://doi.org/10.1002/csc2.20978
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