Brewing yeast disintegration for protein release by horizontal disk milling

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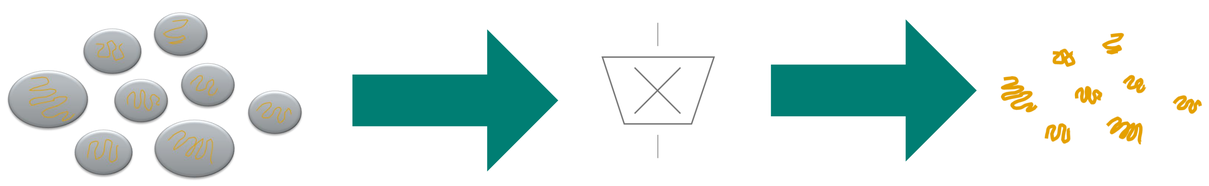
Food processing side streams for alternative proteins

Brewing process

Side stream



Side streams in food processing

- Side streams usage considered beneficial from an environmental perspective[1].
- Demand for alternative proteins requires an understanding of their functional performance[2].

Processing and structure

- We present an approach for disintegration of yeast cells from brewing process.
- The proteins available in the yeast cell suspensions are made accessible by using a pilot plant ball mill.
- We study material properties changes of the processed yeast suspensions to evaluate the disintegration process.

Fig. 1 Side stream processes of brewing process provide yeast cell suspensions, a valuable source for proteins. Lower right: Grey structures indicate yeast cells and yellow structures indicate proteins.

Yeast suspensions and wet grinding

- The yeast cell disintegration was carried out on a LabStar horizontal ball mill.
- The product is conveyed into the grinding chamber from above by the pump and exits again at the front.
- Passage process was chosen to allow for narrowest residence time distribution and correlating precisely the specific grinding energy with the observed material properties.
- Yeast suspension samples were taken after the respective passages for characterization.
- An additional long-time test in recirculation was carried out.

Fig. 2 Horizontal ball mill setup.

Rheological characterization

- A Kinexus Prime Ultra+ rotational rheometer equipped with a Peltier concentrical cylinder geometry (C25) was used.
- Measurements were carried out at 25°C.
- Measurements were carried out in the form of viscosity curves with increasing shear rate using steady state criterion for each final results point.

Fig.3 Schematic of the concentric cylinder geometry.

Differential scanning calorimetry

- Possible changes to the protein structure were studied using differential scanning calorimetry.
- A DSC 300 Caliris® Supreme was used.
- The sample volume was 25 µl each.
- Aluminum *Concavus*®crucibles were used and immediately sealed after filling.
- The samples initially cooled down to 0°C and heated to 90°C after an isothermal step of 3 minutes, heating rate of 5K/min.
- The first heating was followed by a cooling step, from 90°C to 0 °C, heating rate of 10K/min.
- The heating step was repeated under the same conditions.

Fig.4 Schematic of the DSC sample holder.

Effect of yeast cell disintegration on rheological and thermal properties of yeast cell suspensions

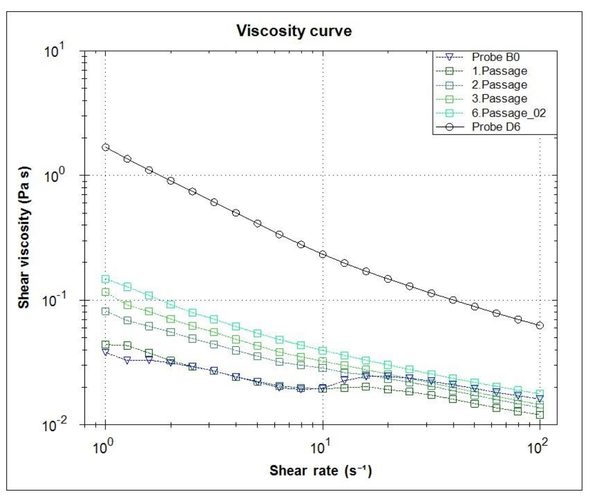


Fig. 5 Shear viscosity curves for yeast cell suspensions after different numbers of passages.

Shear viscosity curves

- An increase in the shear viscosity at lower shear rates (< $10s^{-1}$) can be found with increasing numbers of passage.
- A “bump” in shear viscosity at around $10s^{-1}$ to $20s^{-1}$ can be found for the sample B0 (before cell disintegration) and after the 1st passage. This “bump” has not been found for any other sample.
- The long-time recirculation yields the highest shear viscosity curve.
- Possible mechanisms for increased shear viscosity with increasing number of passages:
  - Release of cell components from inside of the cell yields higher number of dispersed particles / droplets / molecules
  - Swelling of dispersed particles
- Possible explanation for the existence of the “bump”: Cell aggregation at intermediate shear rates

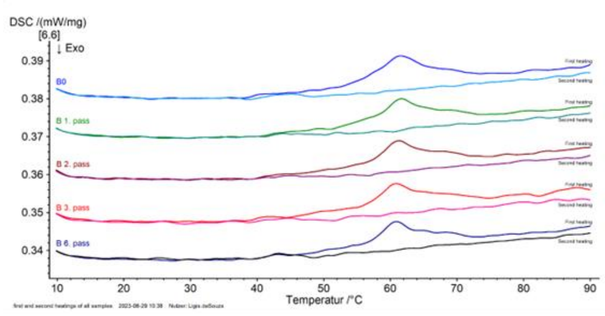


Fig. 6 DSC curve of all samples, first heating with analysis.

DSC measurements

- There was no thermal event observed during the second heating (data not shown here). Meaning the irreversible change on the chemical structure of the released material?
- DSC curves covering a temperature range of 0°C to 90°C show an endotherm peak at approximately 61°C.
- The area of this peak decrease is biggest after the 6th passage which can potentially be linked to the degradation of cell material.

Conclusion and outlook

- The change in the shear rheological properties of the brewing yeast suspension indicate a structural change in the yeast suspension due to cell disintegration.
- We assume that the number of dispersed structures increases due to cell disintegration, causing increase in shear viscosity of the measured shear rate range.
- The observed 61 °C peak area decrease can be explained by potential changes of certain cell materials after the 6th passage. The endothermic effect observed during the first heating was not observed during the second heating. Indicating irreversible chemical reaction. (for example, protein denaturation)

References

1. Mishra, K. Et al. (2024). Valorization of cocoa pod side streams improves nutritional and sustainability aspects of chocolate. Nature Food, 5, 423-432.
2. Ma, K.K. et al. (2022). Functional performance of plant proteins, Foods, 11, 594.