WHC in mushroom in relation to its material property

Conceptual process design of mushroom processing

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Contents

• Project background
• WHC loss in mushroom
• Theory and modelling
• Results
• Conclusion
Background
Canned mushroom: production process

1. Fresh mushroom
2. Vacuum Hydration
3. Storage
4. Blanching at 90°C
5. Sterilising in can at 130°C
6. Slicing at 20°C
7. Canned mushroom 70%
Thermal processing shrink mushroom

Graph showing the relationship between temperature (T (°C)) and relative weight (HC%). The graph indicates a decrease in relative weight as temperature increases, with a significant drop around 60°C. The chart also includes a bar graph showing stages such as Fresh, Hydration, Storage, Blanching, Cooling, Slicing, Sterilize, with the relative weight indicated for each stage.
....and Why?

Protein Denaturation

S. Zivanivic and R. Buescher
Anantheswaran RC et. al (1986);
Beelman RB (1973);
Lin Zhimin (2001);
Eby et al (1975);
Gormley TR and Walshe PE(1986)
Objectives

- Describe the WHC loss in mushroom during thermal processing with the Flory Rehner’s theory
Theory
WHC definition and understanding

Synonyms: water hydration capacity, water absorption, water-imbibing, water-binding etc.

Water Holding Capacity (WHC) – The ability of meat to retain its inherent moisture even though external pressures (like gravity, heating, centrifugation, pressing) are applied to it. This characteristic can be measured by drip loss, but other methods can be used as well (Honikel and Hamm, 1994; Honikel, 1998).

The ability of meat to retain both inherent water and added water is defined as water-holding capacity (WHC) (Grau and Hamm, 1956).
Water holding capacity: Flory Rehner’s theory

- WHC: Ability to hold water under applied external force
- FR theory: WHC expressed as swelling of polymer
- Driving force for dewatering: $\Pi = \Pi^+ + \Pi^- - \Pi$
WHC-determination: centrifugation

- Sample centrifuged at various speeds till equilibrium ($\bar{\Pi} = \Pi$)

\[ \Pi = \Pi_0 + \Pi - \Pi \]

Centrifugation technique
The swelling contributions

\[ p_{ext} = \Pi_{sw} = \Pi_{mix} + \Pi_{ion} - \Pi_{elas} \]

\[ \Pi_{mix} = \frac{RT}{V_w} \left[ \ln(\phi_w) + \left(1 - \frac{1}{N_{eff}}\right)(1 - \phi_w) + \chi_{eff}(1 - \phi_w)^2 \right] \]  

Flory Huggin’s Theory

\[ \Pi_{ion} = \frac{RT}{v_w} \log(a_{w,ion}) \]

Calculated

\[ \Pi_{elas} = \frac{RT}{v_w} N_c \phi_0 \left[ \frac{1}{2} \left( \phi / \phi_0 \right) - \left( \phi / \phi_0 \right)^{2/3} \right] \]  

Estimated
Calculation of mixing pressure

- Mixing pressure was computed from the composition of blanched mushroom (Sman, 2013)

\[
\Pi_{mix} = \frac{RT}{V_w} \left[ \ln(\phi_w) + \left(1 - \frac{1}{N_{eff}}\right)(1 - \phi_w) + \chi_{eff}(1 - \phi_w)^2 \right]
\]

\[
\frac{1}{N_{eff}} = \frac{\sum_{i \neq w} \phi_i / N_i}{\sum_{i \neq w} \phi_i}
\]

\[
\chi_{eff} = \frac{\sum_{i \neq w} \phi_i \chi_{iw}}{\sum_{i \neq w} \phi_i}
\]

<table>
<thead>
<tr>
<th>Components</th>
<th>(\chi_{iw})</th>
<th>(1/N_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mono- saccharides</td>
<td>0.27</td>
<td>0.16</td>
</tr>
<tr>
<td>Di-   saccharides</td>
<td>0.53</td>
<td>0.84</td>
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<tr>
<td>Polymers</td>
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<td>0</td>
</tr>
<tr>
<td>Proteins</td>
<td>0.8-1.4</td>
<td>0</td>
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</tbody>
</table>

- Protein denaturation affects \(\chi_{eff}\) via an effect on \(\chi_{1,p}\)
Modelling and curve fitting
WHC in the heat treated sample

- Moisture content vs. Temp (°C)
- Polymer volume fraction vs. Swelling pressure (Pa)

Graphs showing the relationship between moisture content and temperature, as well as polymer volume fraction and swelling pressure.
Assumptions and verification

Sorption isotherm of freeze dried mushroom (30, 60 and 90°C)
The fitting

\[ \phi_0 \]

\[ T(°\text{C}) \]

\[ \Pi_{\text{swell}} (\text{Pa}) \]

\[ n = - \frac{1}{2} \left( \begin{array}{c} \text{() - (}} \right)^2 \]
Summary and Conclusion

• Describes the water contained in the gel phase
• Need a consideration for water contained in the capillaries
Thank you for your kind attention

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