Magnetic nanoparticles in beverage industry

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InoVine d.o.o.
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InoVine – who are we

InoVine – spin off from IJS - engineering and consulting company, specialized in processing technologies for the wine and beverage industry
- prof. dr. Marin Berovič
- Uroš Pečaver
- doc. dr. Sašo Gyergyek
- Milan Vitas
- Miha Kavčič
- dr. Stanislav Čampelj

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Nanoparticles in beverage industry

- Why use the nanoparticles?
- What properties are required?
- When to use them?
Sparkling wine (champagne, prosecco, cava…)

Production of sparkling wine:
- 1\textsuperscript{st} fermentation – production of still wine, all sugars are fermented
- Addition of sugar (determine the overpressure) and yeast (champagne strain)
- Mixture is in filled in special bottles (traditional method), crown cap
- 2\textsuperscript{nd} fermentation in bottle (traditional method and ancestral method)
- After 2\textsuperscript{nd} fermentation wine lies on yeast, lees for 18+ months
- Bottles are gradually positioned to vertical position (2-10 weeks)
- Sediment is gathered in bottle’s neck
- Neck is cooled and bottle opened – pressure pushes the sediment
- Addition of liqueur and bottle is closed with cork cap
Clarification – riddling or *remuage* (fr.)

The most time consuming step in production, gravity driven
Traditional way – bottles are rotated by hand, each time slightly more vertical
Modern way – bottles are stacked on gyropaletts

Goal: shorten time and reducing the cost of riddling
Functionalization of particles

Nanoparticles – as synthesized
- Superparamagnetic $\gamma$-Fe$_2$O$_3$
- Hydrated surface
- Non-specific adsorption
- Pronounced agglomeration
- Dissolves at pH 3.5 (wine)

Microorganisms surface
- carboxyl group –COOH
- phosphate group –PO(OH)$_2$
(3-Aminopropyl)triethoxysilane

Functionalization
- Simple reaction for functionalization
- No leaching from surface – chemically stable
- Prevents excessive agglomeration
- Positive charge at pH 3-4
- Electrostatic interaction with microorganisms

\[
\text{H}_2\text{O} + (\text{CH}_3\text{CH}_2\text{O})_3\text{Si}(\text{CH}_2)_3\text{NH}_2 \rightarrow \text{Si}(\text{CH}_2)_3\text{NH}_2 + 3\text{CH}_3\text{CH}_2\text{OH}
\]
Magnetic separation

- Opening of the bottle, cooled to 7°C or lower
- Mounting the collection chamber on bottle
- Injection of nanoparticles’ suspension
- Installation of bottle on the magnetic separator
- Lowering of ring with magnets (several times)
- Closing the collection chamber
- Removing the collection chamber
Result of magnetic separation

Turbidity: 1,3 NTU
Effect of magnetic nanoparticles on wine

7 different wines – comparison between treated and untreated wine
7 evaluators (2 enologists)

<table>
<thead>
<tr>
<th>Wine</th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose</td>
<td>3,6</td>
<td>3,0</td>
</tr>
<tr>
<td>Zelen 1</td>
<td>3,6</td>
<td>3,4</td>
</tr>
<tr>
<td>Chardonnay</td>
<td>3,6</td>
<td>3,5</td>
</tr>
<tr>
<td>Rebula</td>
<td>3,0</td>
<td>2,5</td>
</tr>
<tr>
<td>Zelen 2</td>
<td>3,8</td>
<td>3,8</td>
</tr>
<tr>
<td>Rose sparkling wine</td>
<td>3,2</td>
<td>3,4</td>
</tr>
<tr>
<td>White sparkling wine</td>
<td>3,6</td>
<td>3,4</td>
</tr>
</tbody>
</table>
Conclusions

- Yeast and magnetic nanoparticles are bound by electrostatic interaction
- Yeast is removed by magnetic field
- Time is reduced - cca. 3 hours
- Required clarity/turbidity is achieved
- No significant influence on the wine
Acknowledgment

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Thank you for your attention