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Property improvement of mixed dairy and plant-based yogurt alternatives using formulation and lactic acid bacteria co-cultures
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CONTEXT
In a chemically defined medium containing casein and lupin proteins as sole nitrogen sources, positive interactions were observed in co-cultures that associated a proteolytic strain, either Enterococcus faecalis (Efa) or Lactococcus lactis (Lla), and a non-proteolytic strain, Lactiplantibacillus plantarum (Lpl). The positive interactions were mediated by the peptides and amino acids provided by the proteolytic strains and were stronger with Efa (Canon et al., 2021). The aim of the study was to evaluate the impact of these positive interactions on the organoleptic and textural properties of mixed dairy and plant-based yogurt alternatives (YAs).

Preparation of yogurt alternatives (YAs)
As lupin proteins are associated with unpleasant flavour, two different milk:lipin protein ratios were tested (67:33 and 50:50). In order to substitute animal-based fat by plant-based fat, anhydrous milk fat and coconut oil were also tested.

RESULTS

BACTERIAL GROWTH

- Total bacterial counts reached $10^6$ cfu/ml in each YA.
- Protein ratio and fat type had no impact on bacterial growth (Fig. 1) and acidification (Table 1).
- Lpl reached a significantly higher proportion when co-cultured with Efa compared to Lla (Fig. 2).

PROTEOLYSIS

- Proteolysis was impacted by the starter and the protein ratio but not by the fat type.
- Efa showed a strong proteolytic activity and hydrolysed both milk and lupin proteins (Fig. 2).
- Protein hydrolysis was hardly observed with Lla.
- Lpl decreased the levels of free NH$_3$ compounds.

Fig. 1. Percentages of the Lpl strain in co-cultures.

Fig. 2. SDS-PAGE and quantification of free NH$_3$ groups.

SENSORY ANALYSIS

- YAs were differentiated according to the protein ratio (Dim3) and the fat type (Dim2) but not the starter (Fig. 3).
- The protein ratio of 67:33 was described as pleasant, textured (hard gel) and nonhomogenous as opposed to the ratio 50:50 described as unpleasant, bitter and with a mellow texture (Fig. 3).
- AMF was described as milky, lactic and “goaty” and COCO as fruity, fresh and nutty.

Table 1. Physical properties of the 20 yogurt alternatives according to fat, protein ratio and cultures.

<table>
<thead>
<tr>
<th>Fat type</th>
<th>Protein ratio (% milk:lipin)</th>
<th>Efa</th>
<th>Lla</th>
<th>Lpl</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHC (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COCO</td>
<td>50:50</td>
<td>74.9</td>
<td>61.2</td>
<td>61.1</td>
<td>2.2e-16</td>
</tr>
<tr>
<td>AMF</td>
<td>50:50</td>
<td>74.4</td>
<td>60.6</td>
<td>60.6</td>
<td>2.2e-16</td>
</tr>
<tr>
<td>Firmness</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COCO</td>
<td>50:50</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>2.2e-16</td>
</tr>
<tr>
<td>AMF</td>
<td>50:50</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>2.2e-16</td>
</tr>
<tr>
<td>Water holding capacity (WHC %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COCO</td>
<td>50:50</td>
<td>74.9</td>
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</tr>
</tbody>
</table>

a,b,c,d: statistical differences between cultures in the same row.

For each property, the color scale from red to green represents the highest and lowest value, respectively.

- Only the YAs fermented by Efa did not reach the targeted pH within 12 h incubation.
- Lla acidified faster, followed by Efa and Lpl. In both co-cultures, the acidification rates did not differ from that of Efa and Lla cultures (Table 1).
- Apparent viscosity at 50 s$^{-1}$, firmness and WHC were significantly higher for YAs containing AMF, with a milk:lipin protein ratio of 67:33, and fermented with Lla or Lla x Lpl.
- The association Lpl x Efa resulted in more viscous and firmer YAs, as well as less wheying off, compared to the YAs fermented with Efa alone.

CONCLUSION

- 12 yogurt alternatives were prepared.
- With positive interactions (Efa x Lpl), both strains contributed to the final properties of the YAs. Without positive interactions (Lla x Lpl), only Lla contributed in the final properties of YAs.
- More textured YAs (firmer, less wheying off, more viscous) were obtained with anhydrous milk fat and a milk:lipin protein ratio of 67:33.
- Substitution of milk protein by lupin protein can be acceptable, in terms of flavour and texture, if the milk:lipin protein ratio is about 67:33.
- Coconut oil and anhydrous milk fat gave different physical properties that were not perceived during the sensory analysis. Substitution of animal-sourced fat by plant-based one is thus achievable.

REFERENCES


Fig. 3 Correspondence analysis map of sensory analysis (sorting task) data obtained for the 8 YAs fermented with Lla and Lla x Lpl.