

Indigenous *Lactococcus lactis* with probiotic properties: Evaluation of wet, thermally- and freeze-dried raisins as supports for cell immobilization, viability and aromatic profile in fresh curd cheese

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Abstract

Indigenous *Lactococcus lactis* enriched raisins were incorporated in fresh curd cheese in wet, thermally dried, and freeze-dried form to produce a novel probiotic dairy product. Probiotic properties of *Lactococcus lactis* LL16 were evaluated in previous studies. Thus in this study the viability of *L. lactis* cells was assessed in the cheeses during storage at 4 °C for 1, 7, and 14 days and the effect of the added enriched raisins on physicochemical parameters, microbiological characteristics, sugar content, aromatic profile and sensory acceptance of cheeses were evaluated. Results showed that the nature of *L. lactis* LL16 (free or immobilized cells), the support (raisins/immobilized cells on raisins) and the nature of immobilized cultures on raisins (wet or dried) had a significant ($p < 0.05$) effect on cheese pH, moisture, and lactococci counts. Immobilized *L. lactis* cells maintained viability at necessary levels (> 6 cfu/g) during storage and significantly increased the acceptability of cheese. Control cheeses were the least acceptable, while cheese samples with *L. lactis* and raisins, which had the highest lactococci counts, expressed the highest scores in overall sensory acceptability among all samples. Only the addition of thermally dried raisins with immobilized *L. lactis* LL16 cells resulted in an increased cheese sensory acceptability by the end of the storage. This finding might be influenced by a significant increase in total sugars and volatile compounds in this sample. Overall, the addition of raisins enhanced the volatile profile of cheeses with 2-furanmethanol, 1-octanol, 3-methylbutanal, 2-methylbutanal, 2-furancarboxaldehyde, 1-(2-furanyl)-ethanone, 5-methyl-2-furancarboxaldehyde. The obtained results are encouraging for the production of novel fresh cheeses with improved sensorial and functional characteristics on industrial and/or small industrial scale.

Introduction

The latest trend in the development of probiotic enriched food product is the usage of wild-type, indigenous novel potential probiotics isolated from various local sources. Moreover, the use of local and natural prebiotics as a support for the viability of such bacteria is highly encouraged by the consumers. Therefore, this study evaluated the possibility of enriching fresh sweet curd cheese with indigenous *Lactococcus lactis* strain immobilized on raisins and subsequently dried by various methods (wet, thermal drying, freeze-drying).

Aims & Objectives

The objectives of this study were as follows: 1) to produce wet, thermally, and freeze-dried immobilized cultures of indigenous *Lactococcus lactis* strain with presumptive properties on raisins; 2) to supplement traditional sweet curd cheese with *Lactococcus lactis* strain immobilized on raisins; and 3) to evaluate the effects of this supplementation on the physicochemical, microbiological, and sensory parameters of the obtained cheese during its refrigerated storage.

Results

Results show that a gradual growth in lactococci counts was observed in all samples with immobilized cells throughout the storage, however thermally dried cells expressed the lowest counts, compared to wet and freeze-dried cells ($p < 0.05$).

A total of 54 volatile compounds were identified from cheese samples during storage, using HS-SPME extraction method and GC-MS analysis: 5 esters, 8 acids, 8 alcohols, 18 carbonyl compounds and 15 miscellaneous compounds were found.

Microbiological analysis revealed that all immobilized cells demonstrated steady gradual growth in lactococci counts throughout the storage of cheese with thermally dried cells expressing the lowest counts, compared to wet and freeze-dried cells.

Conclusion

Obtained results were ambiguous: even though the growth of lactococci was slower in cheese samples with thermally dried immobilized cells on raisins, preliminary overall sensory evaluation results indicated that this supplementation was the most acceptable by the end of the cheese storage. Therefore, in future studies, lower thermal drying temperature should be considered in order to increase the viability of probiotic cells.

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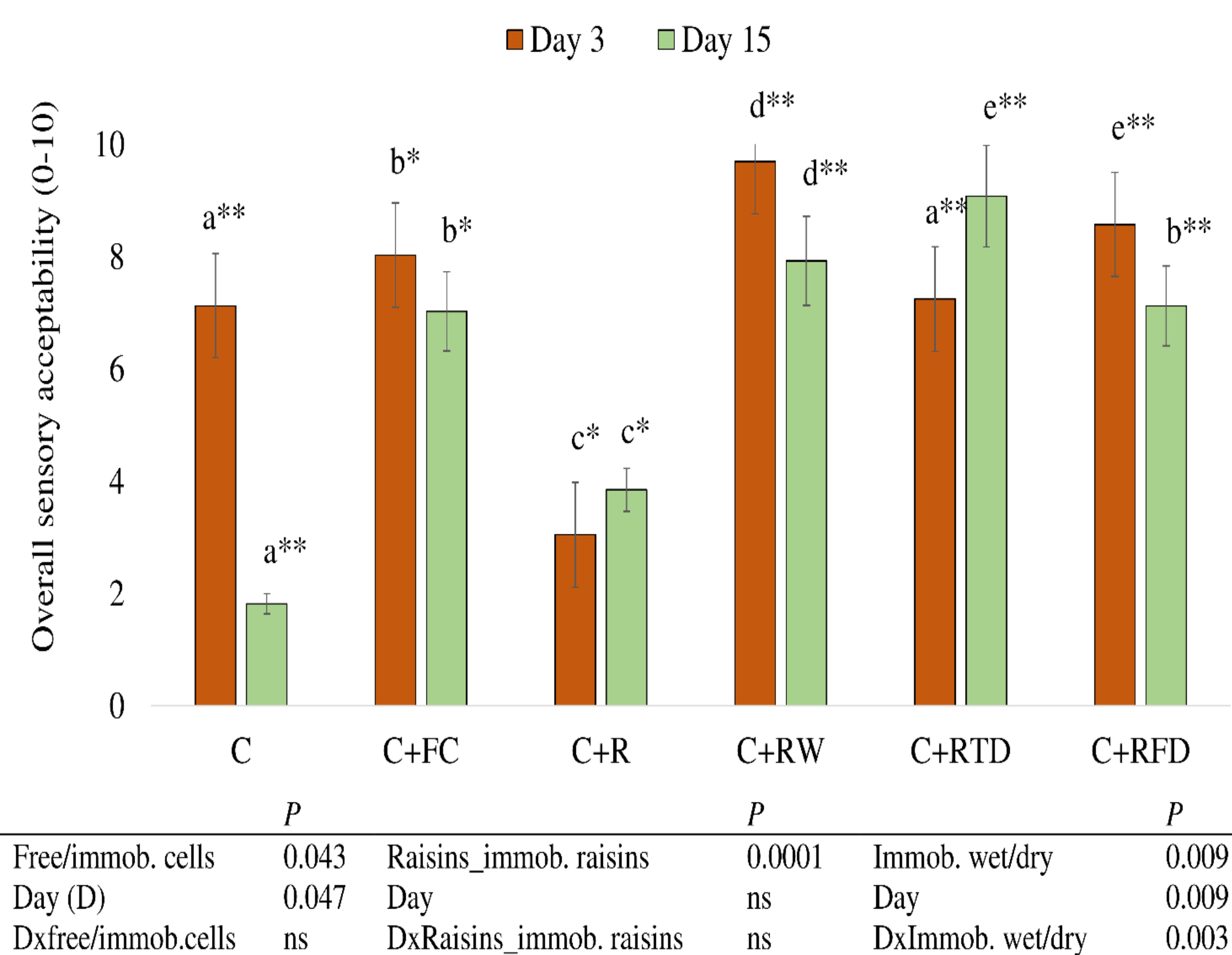


Figure 1. Overall sensory acceptability of sweet curd cheese with *Lactococcus lactis* LL16 cells immobilized on raisins on days 3 and 15 of storage.

Samples: control cheese (C); cheese with free cells (C+FC); cheese with raisins (C+R); cheese with wet immobilized cells on raisins (C+RW); cheese with freeze-dried immobilized cells on raisins (C+RFD); cheese with thermally dried immobilized cells on raisins (C+RTD). No significant differences were found among samples with the same letters within the same day. Differences between storage days for the same sample were significant when $p < 0.001$ (*), $p < 0.0001$ (**). ns: not significant.

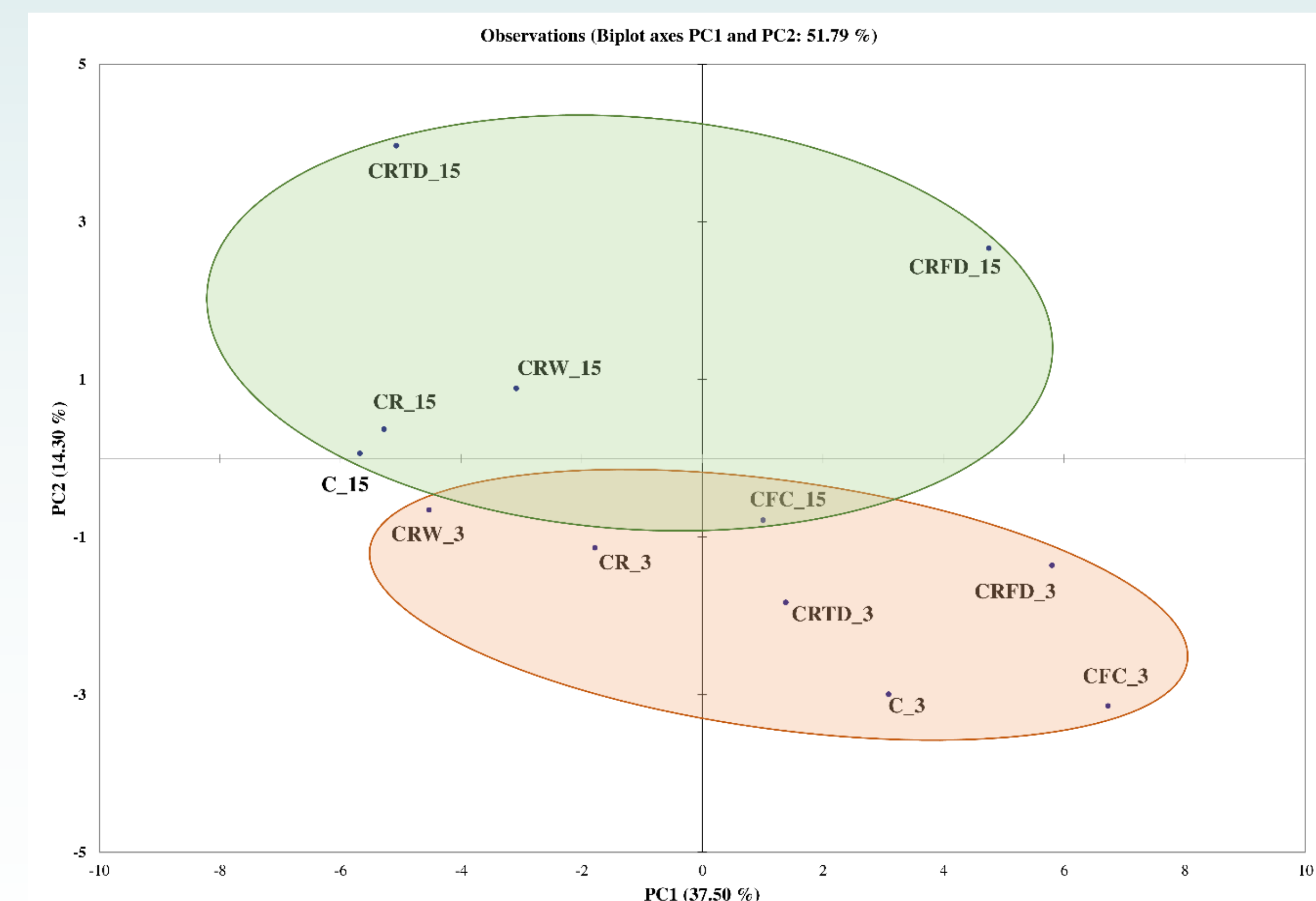


Figure 2. Score plot of the principal components (PC) of minor volatile compounds during storage days 3 and 15 of sweet curd cheese with *Lactococcus lactis* LL16 cells immobilized on raisins.