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Comparison between different agri-food residual streams as direct source of biosurfactants

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Abstract In this work various residues were evaluated as direct source of biosurfactants, observing that those coming from the wine, cider, and potato chip industries exhibited limited potential as direct sources of biosurfactants. Consequently, it should be recommended to evaluate their use as nutritional supplement with other residues in controlled fermentation process rather than use them as direct source of biosurfactants. Notably, winery streams exhibited a lower profile for the spontaneous generation of biosurfactants.
In contrast, dairy products, particularly sour buttermilk, olive oil residues, and Brewer's spent grain residues, gave promising results for considering them as natural sources of biosurfactants. These biosurfactants were able to reduce water surface tension (ST) by approximately 20 units exhibiting in some cases critical micellar concentration (CMC) values lower than 0.1 g/L.
Furthermore, this study aligns with previous research where it was demonstrated the effectiveness of corn steep liquor, a subproduct of wet corn milling industry as direct source of biosurfactants.

Keywords: circular economy, biosurfactant, surface tension, secondary streams, valorization

1. Introduction

Biosurfactants are amphipathic compounds that reduce the surface tension (ST) of water with multiple properties for the cosmetic, pharmaceutical, agriculture and environmental industry (Santos et al., 2024), as it can act as booster of several formulations improving their properties (Rodríguez-López et al., 2019). Usually, biosurfactant extracts are produced in controlled fermentation what suppose an increase in the cost of biosurfactants respect to chemical or bio-based surface-active compounds (Santos et al., 2024).

Few studies exist about the production of more cost competitive biosurfactants produced in spontaneously fermented streams from food industry, except those work related with the production of biosurfactants from corn steep water (Vecino et al., 2023) which is referenced in two patents (ES 2795574 B2 (WO2020/234501) (López-Prieto et al., 2020) and ES 2435324 B2 (WO2014/044876) (Moldes Menduiña et al., 2014)) that highlight the novelty of these kind of alternatives for obtaining new biosurfactant extracts, focused on circular economy aims to implement the best available techniques focused on sustainable practices. Based on that, this study explores the potential of various agri-food residues, including olive oil, wine, cider, brewery, potato, and dairy streams, for direct biosurfactant extraction. For that, these residues were subjected to extraction using ethyl acetate or phosphate buffer saline (PBS), without previous additional fermentation or after various days of natural fermentation.

2. Materials and Methods

2.1. Extraction and characterization of Biosurfactant extracts

Extraction of biosurfactants were carried out with saline buffer phosphate (PBS) or ethyl acetate based on patents ES 2795574 B2 (WO2020/234501) and ES 2435324 B2 (WO2014/044876) respectively. The extraction with PBS was limited to the solid fraction of the residues, previously centrifuged, to extract biosurfactants associated with the cell membrane of microbial biomass present in the residual streams. Conversely, the extraction with ethyl acetate was applied to the entire residue or to the liquid phase. The ethyl acetate was removed after distillation, and the biosurfactants were dissolved in water at a concentration of 1 g/L and serial dilutions were made and surface tension was measured at different concentrations to evaluate their surfactant properties. These properties were measured using a tensiometer K20 EasyDyne equipped with a 1.9 cm platinum Wilhelmy plate.

3. Results and discussion

Figure 1 shows the ST values obtained from the different BS extracts, starting from an initial concentration of 1 g/L and using serial dilutions, while Table 1 shows the ST and critical micellar concentration (CMC) of water in presence of the biosurfactant extracts under evaluation at concentrations of 1 g/L.

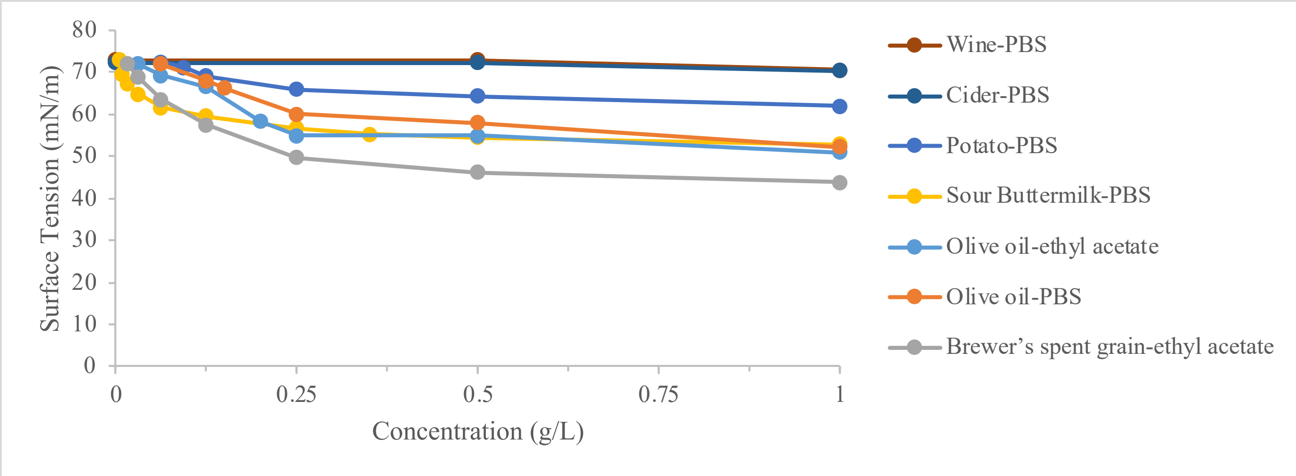

Figure 1. Minimum ST and CMC values obtained from the BS extracts of different residual sources and extraction method

Table 1. Minimum ST at 1 g/L and CMC values obtained from the BS extracts of different residual sources and extraction method

BS Residue Source	Min ST (mN/m)	CMC (g/L)
Wine-PBS	70.5	ND*
Cider-PBS	70.3	ND*
Potato-PBS	61.9	0.20
Sour buttermilk-PBS	52.9	0.08
Olive oil-ethyl acetate	50.9	0.27
Olive oil-PBS	52.2	0.27
Brewer's spent grain-ethyl acetate	43.8	0.18

***ND: not determined**

A progressive decrease in surface tension was observed with increasing dilution, indicating the activity and concentration-dependent behavior of the extracts. The differences among the extracts suggest variability in biosurfactant efficacy depending on the source material or extraction method. The BS extracts obtained from Wine and Cider with PBS did not reduce the ST below 70 mN/m, which did not allow obtaining CMC values, being similar to the case of the BS extract obtained from Potato with PBS which did not significantly reduce ST. Meanwhile, the BS extracts obtained from sour buttermilk, olive oil residues, and Brewer's spent grain with PBS, and also with ethyl acetate in the case of olive oil, were able to reduce ST to below 53 mN/m, representing a decrease of more than 20 units compared to the initial value. Among them, the BS extract obtained from Brewer's spent grain with ethyl acetate showed the lowest ST value with a reduction of almost 30 mN/m. However, in terms of CMC, the BS extract derived from sour buttermilk exhibited the lowest CMC value, below 0.1 g/L, which is less than half the value observed for the other residues tested.

4. Conclusion

This work suggest that BS extracts obtained from Wine, Cider and Potato, are not a suitable alternative to other sources of BS since they do not significantly reduce the ST of water. But the BS extracts obtained from sour buttermilk, olive oil residues, and Brewer's spent grain residues obtained more promising results, managing to reduce the ST by 20 units, highlighting the CMC values of the BS extract from sour buttermilk with a value of 0.08 g/L. While future studies involving greater depth and detail are necessary, such as the inclusion of fermentation time, the present findings highlight the potential of agri-food waste as a viable source of biosurfactants, as previously evidenced by the use of corn steep liquor.

5. References

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