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Circular Economy through Berry Pomace Valorization

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Abstract. This investigation delineates the economic aspects associated with the valorization of pomace derived from ten distinct berry varieties within the context of the circular bioeconomy paradigm. Through the implementation of a comprehensive marketing costs and returns (MCR) analysis, this research evaluates the economic viability and market potential associated with the conversion of berry pomace, an ancillary product of the juice and wine sectors, into high-value commodities. The economic assessment reveals considerable prospects for the development of functional food additives and cosmetic constituents, underscoring the cost efficiency associated with the utilization of berry pomace as a valuable resource. The outcomes indicate that sophisticated analytical techniques, encompassing fermentation and biorefinery processes, may be employed to augment the value of the pomace, thereby fostering increased profitability and market competitiveness for the products generated through this approach. The results imply that the amalgamation of agronomic expertise with economic frameworks can significantly bolster the feasibility of berry pomace valorization, thus aiding rural economies, encouraging sustainable industrial practices, and contributing to the realization of Sustainable Development Goals.

Keywords: Circular Bioeconomy, Berry Pomace, Economic Analysis, Market Viability, Functional Food.

1. Introduction

Recent studies have underscored the potential of berry pomace as a source of potent antioxidants, phenolic compounds, and prebiotic agents beneficial for human health and wellness. The extraction and characterization of these compounds reveal notable antioxidant activities and potential applications in skin care formulations as prebiotic agents that support beneficial microbiota (Ivanković et al., 2024; Frum et al., 2022). Furthermore, economic analyses emphasize that the valorization of such by-products through innovative biorefinery approaches significantly contributes to local economies and promotes sustainable industrial practices (Maggiore & Setti, 2024; Voss et al., 2023). This paper explores the economic viability and market potential of valorizing berry pomace from ten different berry varieties. This research supports the broader aim of fostering sustainable development by optimizing waste valorization processes and enhancing the circularity of the berry processing sector, thereby contributing to the realization of the Sustainable Development Goals.

2. Methodology

This study employed a comprehensive Marketing Costs and Returns (MCR) analytical framework to assess the economic viability of valorizing pomace derived from ten distinct berry varieties. The methodology integrated both qualitative and quantitative economic evaluation tools to estimate profitability, return on investment (ROI), and market sensitivity. The core analysis was structured around two primary valorization scenarios: (1) basic fermentation processes, representing low-complexity, single-product conversion pathways (e.g., ethanol or biomass feed), and (2) integrated biorefinery approaches, which fractionate pomace into multiple high-value co-products such as polyphenol extracts, seed oils, and dietary fibers. For each scenario, data on net profit, operating costs, capital expenditure (CAPEX), and Internal Rate of Return (IRR) were calculated.

3. Results

The economic analysis for ten different berry pomaces reveals substantial variability in profitability across berry types.

Table 1. Profitability and sensitivity analysis for the valorization of pomace from ten berry varieties.

Berry Pomace	Net Profit (€/ton)	ROI (%)	Payback (months)	ROI (price –20%)	ROI (price +20%)
Blackcurrant	400	32	36	12%	52%
Aronia (Chokeberry)	380	30	40	10%	50%
Sea Buckthorn	360	25	43	5%	45%
Cranberry	330	22	48	2%	42%
Blueberry	300	20	60	0%	40%
Elderberry	270	18	66	–2%	38%
Raspberry	240	17	72	–3%	37%
Blackberry	220	15	80	–5%	35%
Redcurrant	180	12	100	–8%	32%
Strawberry	150	10	120	–10%	30%

As results shows, the blackcurrant pomace yields the highest net profit (~€400/ton) and ROI (~32%), reflecting its rich yield of valuable compounds (blackcurrant seeds provide oil high in γ-linolenic acid and the skins are rich in anthocyanins. Close behind are black chokeberry (aronia) and sea buckthorn pomaces, each around €350–380/ton profit with ROI in the mid-20s to 30%. These high-performing cases owe their profitability to multiple co-products: for instance, polyphenol extracts and seed oils contribute significantly to revenue. Importantly, the valorization outcomes are sensitive to product market prices.

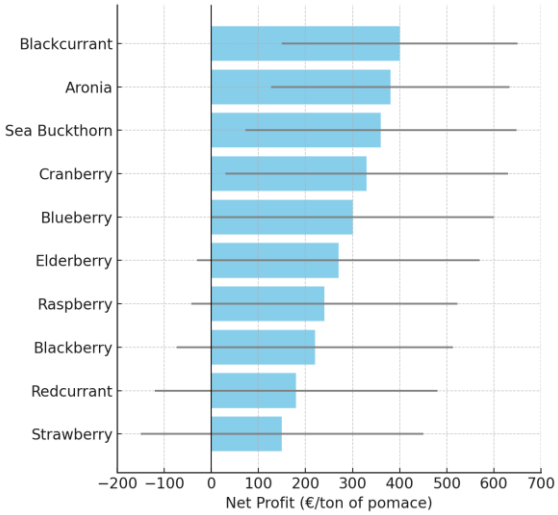

Figure 1. Net profit per ton of pomace for various berry varieties, with error bars indicating the sensitivity to ±20% changes in product selling price.

Higher-value pomaces (top of chart) not only yield greater profits under base conditions but also remain profitable even if product prices decline (leftward gray error bars). Lower-value pomaces (bottom) have slim margins that can turn into losses under a price drop (error bars crossing into negative net profit), highlighting greater economic risk. Price increases (rightward error bars) substantially boost profitability for all cases, roughly doubling the net profit for most berry pomaces. These results underscore that feedstocks rich in bioactive compounds (e.g. blackcurrant, aronia) are far more resilient and lucrative in a circular bioeconomy context than those yielding lower-value products

The biorefinery strategy capitalizes on the full spectrum of valuable constituents in the pomace – from edible oils and antioxidants to fibers and proteins – thus generating enough revenue to offset the higher operating costs and capital requirements. In contrast, fermentation or other low-complexity uses leave much of the potential value untapped.

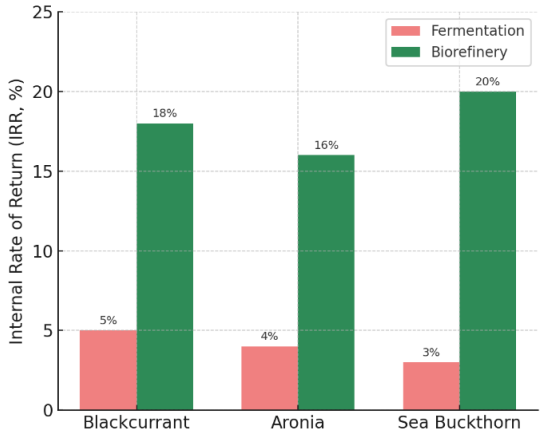

Figure 2. Internal Rate of Return (IRR) comparison between fermentation-based and biorefinery-based valorization for three exemplary berry pomaces (blackcurrant, aronia, and sea buckthorn). The biorefinery approach (green bars) yields IRRs in the 15–20% range, vastly superior to the 3–5% IRRs achieved by simple fermentation (red bars).

This indicates that only the multi-product strategy provides a sufficiently high return on investment to be attractive. Fermentation of these pomaces, while simpler, barely generates enough returns to justify the capital. The figure highlights that upgrading berry pomace into multiple products is economically advantageous relative to single-product conversion, corroborating techno-economic analyses on other fruit wastes. In summary, the results demonstrate that berry pomace valorization is economically feasible and can be highly profitable under the right conditions.

4. Conclusions

This paper explores the economic viability and market potential of valorizing berry pomace from ten different berry varieties. Berry pomace valorization via biorefinery methods demonstrates strong economic viability, particularly for high-value berries like blackcurrant and chokeberry. Effective market strategies and advanced extraction techniques significantly enhance profitability and resource efficiency, supporting sustainable industrial practices and environmental goals.

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