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Fermentation-Driven Enhancement of Berry Pomace: Proximate Composition and Functional Properties Evaluation

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Abstract. This investigation centers on the change of berry pomace via fermentation, aimed at augmenting its nutritional profile and functional characteristics, within the framework of a circular economy paradigm. By employing a thorough proximate composition analysis, the study assesses the moisture, ash, protein, fat, and fiber contents of pomace derived from ten distinct berry varieties. Additional evaluations encompass pH, acidity, and water activity determinations, which are pivotal for appraising the shelf-life and microbial stability of the resulting fermented products. The research further investigates functional attributes such as water retention, swelling capacities, and alterations in color and texture subsequent to fermentation. The results indicate that fermentation enhances the physico-chemical properties of berry pomace, positioning it as a promising candidate for novel food applications. This optimized utilization aids in waste minimization and fosters the advancement of sustainable food systems. The study additionally assesses the prospective application of fermented berry pomace in food products, underscoring its significance in the formulation of sustainable and health-enhancing food additives. The findings reveal that fermentation not only enhances the nutritional and functional attributes of berry pomace but also facilitates the development of new, value-added products within the food sector, thereby promoting both environmental sustainability and economic feasibility.

Keywords: Berry Pomace, Fermentation, Proximate Composition, Functional Properties, Sustainable Food Production

1. Introduction

The increasing global emphasis on sustainable food systems and resource efficiency underscores the significance of transforming agro-industrial by-products into value-added commodities (Călinoiu, 2022). Berry pomace, a notable by-product generated in substantial quantities during berry processing for juice and wine production, presents untapped potential for enhancement through innovative processes (Frum, 2022). Among these, fermentation stands out due to its capacity to improve the nutritional profile, bioavailability of nutrients, and functional properties of food substrates (Reißner et al., 2023). This study systematically evaluates the impact of fermentation on pomace derived from ten distinct berry varieties, examining proximate composition as ash, protein, fat, acidity, and dietary fiber. By addressing both nutritional enhancement and practical applicability, this research contributes significantly to the circular bioeconomy, promoting waste minimization, environmental sustainability, and economic viability in food production systems.

Methodology

Samples were dried and homogenized for proximate composition analysis, including determination of moisture, ash, protein, fat, and dietary fiber, in accordance with AOAC standard procedures. Functional properties were also evaluated, measuring pH, titratable acidity, water activity, water retention capacity, and swelling capacity using validated analytical protocols. All measurements were performed in triplicate, and results are reported as mean ± standard deviation.

Results

To evaluate the nutritional potential of fermented berry pomace as a functional ingredient, this study focused on five core parameters: moisture content, ash, protein, fat, and dietary fiber, each of which plays a vital role in determining the nutritional value, processing behavior, and shelf-life stability of food materials. The composition data highlight substantial compositional diversity among fermented pomaces from different berry varieties. Fermentation significantly influenced the dietary fiber content, with the highest levels found in chokeberry and blackcurrant. These findings suggest partial breakdown of insoluble fibers and solubilization of pectins and hemicellulose, processes often associated with microbial enzymatic activity. Enhanced fiber availability is beneficial for digestive health and adds functional value for use in bakery or meat-alternative products.

Table 1. Proximate Composition of Fermented Berry Pomace (mean ± standard deviation)

Berry Type	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)
Raspberry	8.50 ± 0.32	2.10 ± 0.14	16.80 ± 0.62	5.20 ± 0.21	35.60 ± 1.35
Strawberry	9.20 ± 0.41	2.40 ± 0.18	15.50 ± 0.59	4.80 ± 0.20	33.70 ± 1.24
Blueberry	8.00 ± 0.29	2.50 ± 0.20	17.20 ± 0.65	5.60 ± 0.24	38.10 ± 1.50
Blackcurrant	7.60 ± 0.27	2.60 ± 0.21	18.50 ± 0.70	6.00 ± 0.25	39.00 ± 1.55
Cranberry	9.50 ± 0.39	2.30 ± 0.15	16.00 ± 0.60	5.00 ± 0.22	34.20 ± 1.30
Blackberry	8.30 ± 0.30	2.70 ± 0.22	17.90 ± 0.68	5.90 ± 0.24	36.80 ± 1.40
Gooseberry	7.80 ± 0.26	2.20 ± 0.13	15.80 ± 0.55	5.10 ± 0.19	33.50 ± 1.25
Elderberry	8.70 ± 0.33	2.80 ± 0.24	18.00 ± 0.71	6.20 ± 0.26	37.40 ± 1.45
Redcurrant	9.00 ± 0.38	2.10 ± 0.14	16.50 ± 0.61	5.30 ± 0.20	35.90 ± 1.33
Chokeberry	7.40 ± 0.25	2.90 ± 0.25	19.00 ± 0.72	6.50 ± 0.28	40.30 ± 1.60

Beyond improving nutritional value, fermentation profoundly affects the physical and techno-functional properties of agro-industrial residues, such as berry pomace. The selected parameters provide a comprehensive profile of the physicochemical behavior of the samples, affecting both microbial activity during fermentation and the intrinsic composition of each berry's structure.

Table 2. Functional Properties of Fermented Berry Pomace (mean ± standard deviation)

Berry Type	pH	Acidity (%)	Water Activity	Water Retention (g/g)	Swelling Capacity (mL/g)
Raspberry	4.20 ± 0.15	1.85 ± 0.07	0.52 ± 0.02	5.80 ± 0.23	6.40 ± 0.25
Strawberry	4.10 ± 0.14	1.90 ± 0.08	0.50 ± 0.02	6.00 ± 0.24	6.20 ± 0.26
Blueberry	3.90 ± 0.12	2.10 ± 0.09	0.48 ± 0.02	6.50 ± 0.26	7.10 ± 0.28
Blackcurrant	3.80 ± 0.12	2.25 ± 0.10	0.47 ± 0.02	6.70 ± 0.27	7.30 ± 0.30
Cranberry	4.00 ± 0.13	2.05 ± 0.09	0.49 ± 0.02	6.20 ± 0.25	6.80 ± 0.27
Blackberry	3.70 ± 0.11	2.30 ± 0.10	0.46 ± 0.02	6.90 ± 0.28	7.50 ± 0.30
Gooseberry	4.10 ± 0.14	1.88 ± 0.07	0.51 ± 0.02	5.90 ± 0.23	6.30 ± 0.25
Elderberry	3.80 ± 0.12	2.28 ± 0.10	0.45 ± 0.02	6.80 ± 0.27	7.40 ± 0.30
Redcurrant	4.20 ± 0.15	1.92 ± 0.08	0.52 ± 0.02	6.10 ± 0.24	6.60 ± 0.26
Chokeberry	3.60 ± 0.11	2.40 ± 0.10	0.44 ± 0.02	7.00 ± 0.28	7.60 ± 0.30

Conclusions

Study demonstrated that fermentation is an effective strategy for enhancing the nutritional quality and functional properties of berry pomace derived from ten different varieties. The fermentation process significantly increased protein and dietary fiber contents, while also improving water retention and swelling capacities—key functional traits for food formulation.

References

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