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From Side Stream to Sustainable Food Products: Life Cycle Insights from Chocolate and Granola

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Abstract

Food processing generates substantial quantities of edible side streams that are often used as feed, composted, or valorised energetically despite their remaining nutritional value. In Switzerland, around 27% of the environmental impact of avoidable food losses occurs during food processing. This work assesses under which conditions side stream valorisation into food ingredients delivers measurable environmental benefits, using market-relevant products as case studies. Based on a review of 14 side streams selected according to quantity and environmental relevance, this contribution applies life cycle thinking to compare management and valorisation pathways. Case studies assessed environmental performance in dark chocolate with partial replacement of cocoa nibs by cocoa bean hulls (CBH), and granola containing spent coffee grounds (SCG), coffee silverskin (CSS), or a mixture of both. The assessment considers displaced functions, avoided primary ingredients, and additional burdens from stabilisation, drying, milling, and reformulation. Three main findings emerge. In granola, incorporating coffee side streams reduced overall life cycle impacts, expressed as eco-points (EP) using the ecological scarcity method, by 13.5–16.3% relative to the respective reference products. The SCG-only variant achieved a 16.0% reduction, the CSS-only variant 16.3%, and the mixed SCG/CSS variant 13.5%, with the lower benefit mainly caused by the additional energy demand for mill-drying. In dark chocolate, replacing cocoa nibs with cocoa bean hulls reduced overall environmental impact by 16.0% at 25% nib replacement and by 32.0% at 50% nib replacement, highlighting the benefit of substituting high-impact ingredients. Environmental benefits can only materialise if side stream-based products are technically feasible and acceptable to consumers. In chocolate, cocoa bean hull incorporation increased fibre content and no off-flavours were detected in internal sensory screening, indicating promising market potential. From an implementation perspective, the project furthermore shows that the process can be easily transferred to industrial scale. The environmental benefits of side stream valorisation are most robustly assessed at the level of real food products, where substituted ingredients, additional processing, and feasibility constraints can be considered together. The analysed examples show that meaningful impact reductions are possible, and that the ingredient being replaced is a key determinant of the LCA result. This is clearly illustrated by chocolate, where cocoa bean hulls replace cocoa nibs, the main environmental hotspot of the formulation. Among the assessed valorisation options, incorporating cocoa bean hulls into chocolate provided the greatest environmental benefit, outperforming feed, mulching, and energy recovery pathways.

Keywords: Life cycle assessment, food side streams, upcycling, environmental impact, food loss treatment

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