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FROM FRESH TO RIPENED CHEESE: LINKING ENERGY USE, ENVIRONMENTAL IMPACTS AND NUTRITIONAL VALUE IN A LIFE CYCLE PERSPECTIVE

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Abstract –The dairy sector faces increasing pressure to reduce environmental impacts while maintaining nutritional quality and product diversity. Cheese production is particularly complex, as it involves a wide range of processing technologies and energy demands, from fresh cheeses to long ripened products. This study presents an evaluation based on Environmental Product Declarations and Life Cycle Assessment applied to different cheese typologies. Environmental impacts are assessed across the main production stages within system boundaries covering milk production and cheese manufacturing. Energy consumption is explicitly separated into electricity and thermal energy, allowing the identification of process specific environmental hotspots and improvement options along the production chain. Sensitivity analyses are performed to examine the influence of alternative energy sources, changes in electricity mix composition, and variations in process energy efficiency. This analysis supports the evaluation of result stability and highlights the role of energy related strategies in determining the environmental performance of different cheese categories. To increase the relevance of the results for decision making, environmental impacts are also related to nutritional value through a nutritional Life Cycle Assessment approach. Impacts are expressed in relation to the content of nutrients and selected micronutrients, such as proteins, energy, minerals and vitamins, enabling comparisons that extend beyond product mass and provide a more functionally meaningful assessment of sustainability. The results offer a practical benchmarking framework for the dairy industry and define a robust reference for future comparisons with protein alternatives derived from plant sources. This supports transparent sustainability communication, product design strategies, and evidence-based decision making.

Keywords – Cheese production; energy consumption; Environmental Product Declaration; Life Cycle Assessment; Nutritional Life Cycle Assessment