Composting as an Alternative to Improve the Circularity of Poultry Systems

A Case Study in Mexico

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Introduction

The poultry industry is a critical component of global food systems, providing a significant source of protein (FAO, 2023). However, it also generates substantial environmental challenges, particularly in terms of waste management. Poultry manure, a primary by-product, is rich in nutrients but often underutilized or mismanaged, leading to environmental pollution and resource inefficiency. Composting has emerged as a promising alternative to improve the circularity of poultry systems by transforming organic waste into valuable biofertilizers (Hollas et al, 2022).

This evaluated the impact of composting on the circularity of a poultry system in Mexico, using the farm Avícolas Campesinos Bondojito (ACB) as a case study. The aim is to quantify the benefits of composting in terms of biomass utilization, energy efficiency, and nutrient recycling. The findings are expected to provide actionable insights for improving the sustainability of poultry systems in similar contexts.

Methods

A transdisciplinary approach was employed in the research (Hernández Aguilar, 2018). To this end, the farm system was characterized, identifying the material flows of poultry production and determining their viability as agro-inputs via their transformation into compost. Primary data on poultry manure production and its physicochemical properties were collected over one production cycle. Poultry manure was mixed with straw to achieve an optimal C:N ratio for composting. The mixture was processed in a pilot-scale composting system, where temperature, pH, and electrical conductivity (EC) were monitored regularly. The composting process was evaluated for thermal evolution, sanitization, and nutrient availability. The Nested Circularity Framework was applied to evaluate the impact of composting on the farm's circularity. Key indicators included biomass production, energy efficiency, and nutrient recycling. Each indicator consisted of different variables that were quantified for each scenario. In order to compare them, variables were standardized on a scale from low circularity value (0) to 100% (high circularity value).

Results

FARM CHARACTERIZATION

The results of the farm characterization for 2023 are presented in Figure 1. The farm operates under a contract with an integrator company. The company provides essential inputs: chicks, feed, and technical assistance to the farm. The farm, in return, supplies the infrastructure, labor, and other operational requirements (e.g., water, bedding materials). The average production cycle is 44.6 days, with a chick mortality rate of 4.73% and a feed conversion ratio of 1.69 and a daily manure production of 22.6 g/day per chick. Poultry manure was identified as the primary by-product (Figure 1). Its physicochemical properties included 36.7%C, 3.27%N, 1.51%P, and 2.9%K, with a pH of 7.62, an EC of 1062 µS·cm^{-1}, and a C:N ratio of 11.34:1 (Vandecasteele et al, 2014). These properties limited its direct use as a fertilizer due to instability and potential phytotoxicity (Rynk, 2022).

COMPOSTING EVALUATION

Composting significantly improved the viability of poultry manure as an agro-input. The C:N ratio increased to 31.84, enhancing thermal evolution and sanitization. Nutrient availability also improved, particularly nitrogen (Figure 2). The final compost exhibited stable physicochemical properties (C:N 10.4, pH 8.5, and EC 1,066 µS·cm^{-1}), making it suitable for use as a biofertilizer.

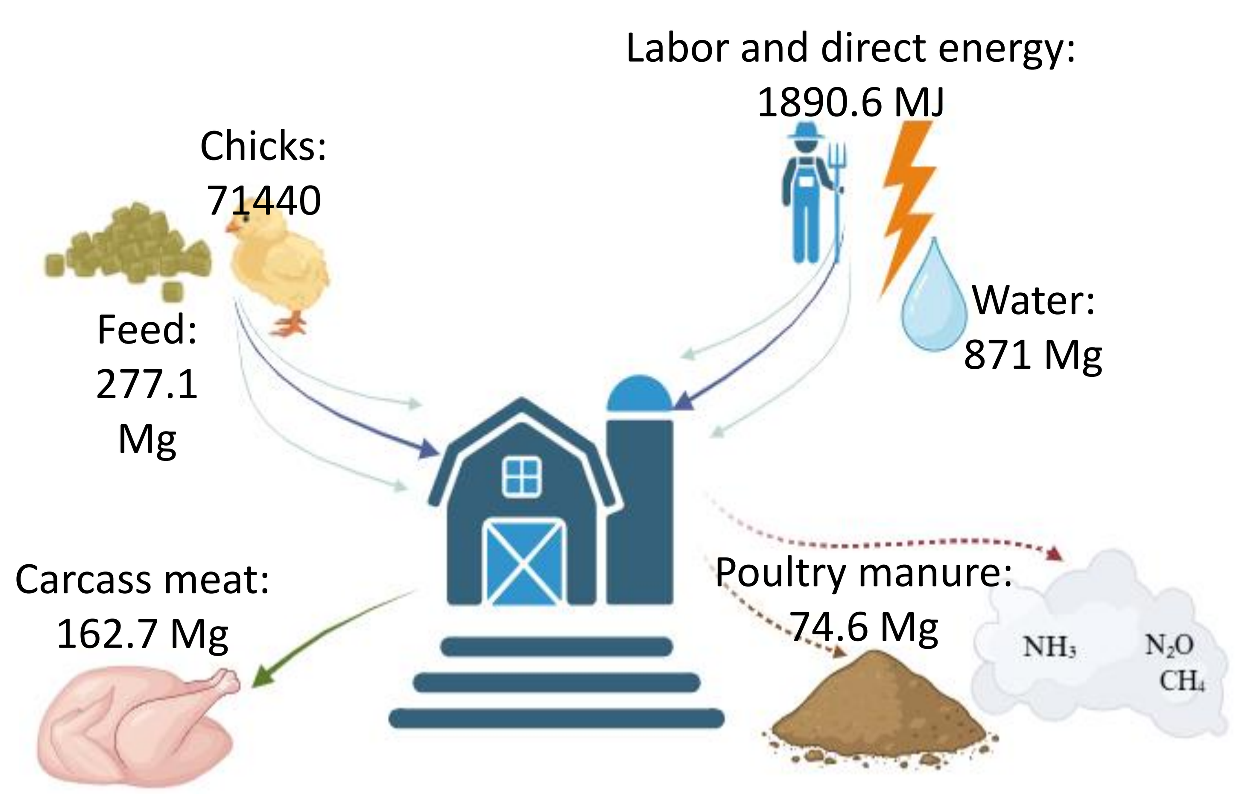

Figure 1. System diagram with material and energy flows.

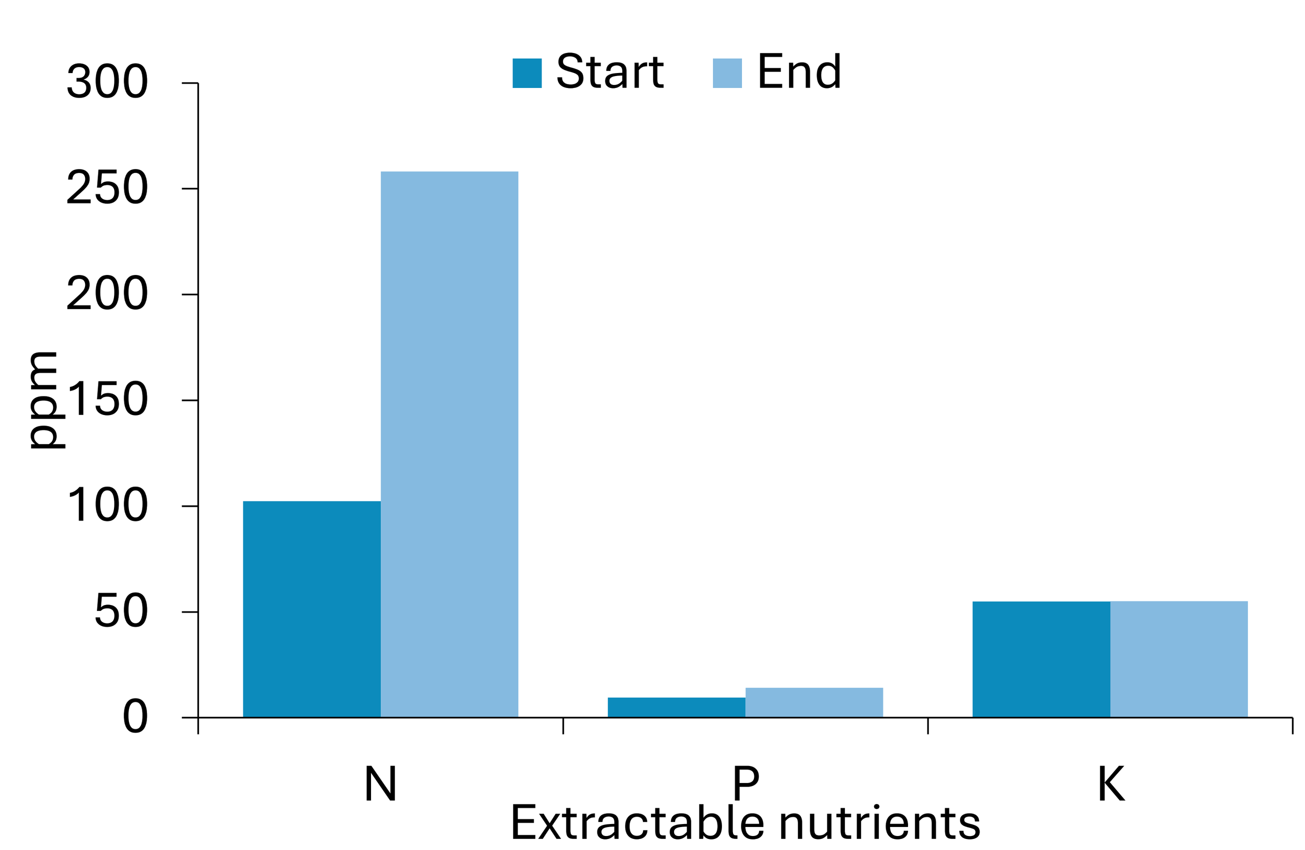

Figure 2. Changes in nutrient extractability in chicken manure compost at the start and the end of composting.

Results

CIRCULARITY ASSESSMENT

Two waste management scenarios were compared: (1) direct application/sale without composting and (2) composting and application as biofertilizer to produce bedding material. The scenario comparison is shown in Figure 3. The addition of composting into the poultry system of Scenario 2 enhanced circularity by improving biomass utilization, reducing reliance on external inputs, and increasing energy efficiency (Figure 3).

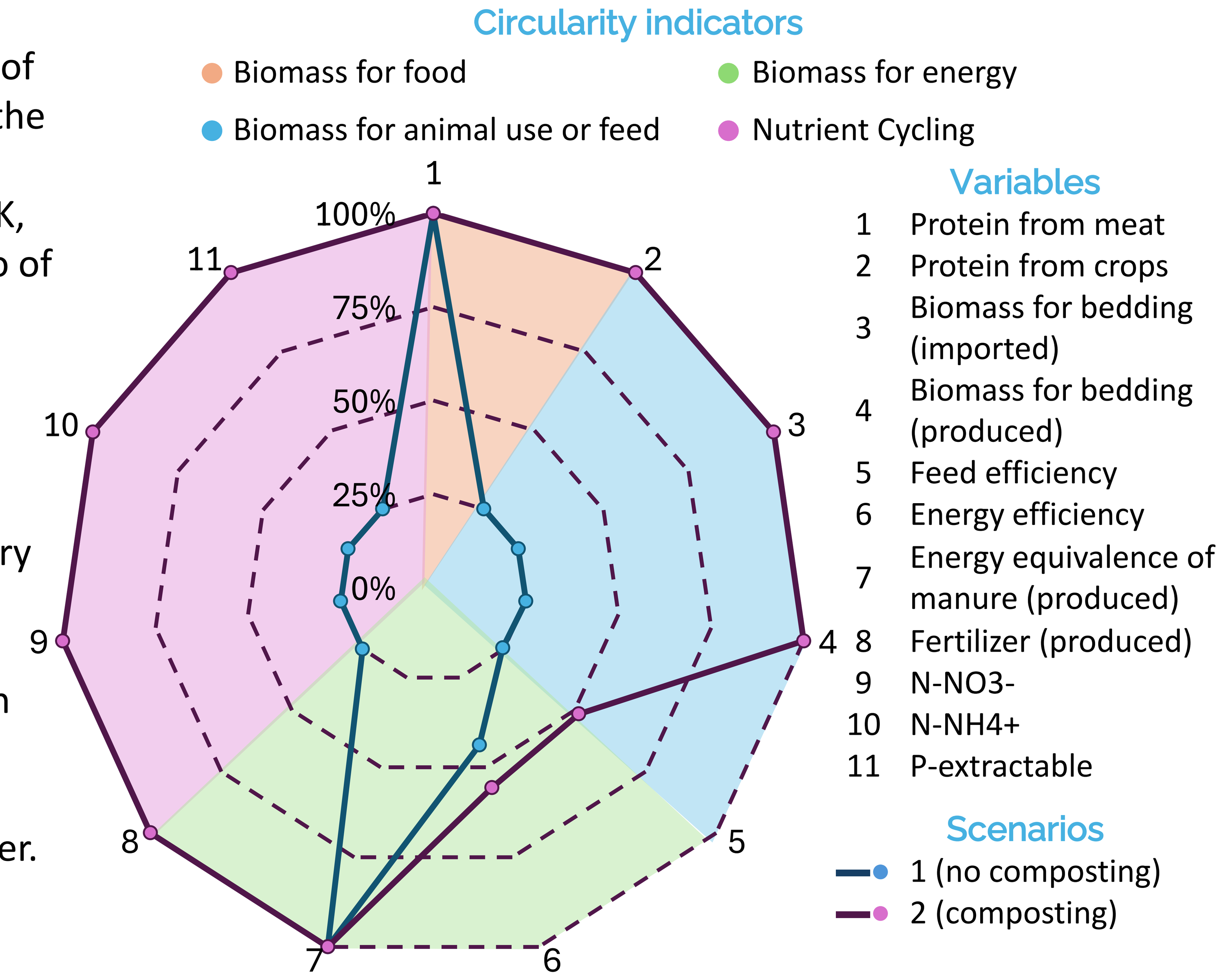

Figure 3. Comparison of two manure management scenarios for a poultry production system. Variables weighed from 0 to 100%.

The additional production of 7.72 Mg of oat grain and 9.6 Mg of straw was achieved, which increased protein for food and eliminated the need for purchasing bedding materials. Energy efficiency improved from 44% in Scenario 1 to 56% in Scenario 2, mostly for the increase in useful products in the system and reduction of waste. Additionally, composting improved nutrient availability in manure, making possible its recirculation into the system.

Thus, the integration of composting with agricultural biomass production significantly improved the farm's circularity. This aligns with the findings of Koppelmäki et al. (2021), who recommend enhancing the circularity of agricultural systems by reducing feed-food competition and nutrient overproduction and waste.

Conclusion

This study demonstrates that composting is a viable alternative to improve the circularity of poultry systems, as evidenced by the case study at ACB. By transforming poultry manure into a high-quality biofertilizer, composting contributes to a more sustainable and efficient production system, aligning with the principles of circular economy. Future efforts should focus on scaling up composting technologies and integrating them into broader agricultural systems to maximize their impact on sustainability and circularity.

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