Efficient Management of Eco-Feed Production from Food Waste in Japan

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In 2022, global food waste amounted to 1.05 billion tons (631 million tons from households and 419 million tons from businesses), translating to an average of 79 kilograms of food waste per person annually, or roughly 1.3 meals per day for those suffering from hunger. Food waste is also a significant issue in Japan, where 24 million tons of food waste were generated in 2021 (16.7 million tons from businesses and 7.3 million tons from households). To address this, 76% (9 million tons) of business sector food waste is recycled into animal feed (eco-feed), promoting the expansion of eco-feed use. This also contributes to improving Japan's low feed self-sufficiency rate.

This research analyzes the production efficiency of 45 eco-feed plants in Japan using Data Envelopment Analysis (DEA). These plants include 28 using the dry production method, 11 using the liquid production method, and 6 using the fermentation production method. While Nakaishi and Takayabu (2022) identified inefficient plants in Japan, they did not differentiate between eco-feed production technologies. Therefore, Nakaishi and Takayabu (2022) failed to establish a reference Eco-feed production frontier for a specific Eco-feed production technology (e.g., dry production method analyzed in this study). The novelty of this study is twofold. First, this study is the first attempt to examine the production efficiency with a focus on a specific Eco-feed production technology. Second, we revealed the increase potential in eco-feed sales, categorized by production method and each plant, as well as the GHG reduction potential based on the efficiency estimated by DEA.

A comprehensive input-output database was compiled for the 45 plants, including inputs such as maintenance fees (JPY) and food waste delivered (t), and the output, which is the amount of Eco-feed produced. The study calculated normalized efficiency scores between 0 and 1 for each plant via DEA, with scores closer to 1 indicating higher efficiency.

Two types of DEA models considering Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) were used in this study. These models helped assess three efficiency types: Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE), allowing for the identification of inefficiencies due to production technology or scale.

The results showed that average OTE scores were 0.44 for the dry method, 0.49 for the liquid method, and 0.47 for the fermentation method, with 37 plants scoring below 1, suggesting significant room for improvement. Average PTE scores were 0.55, 0.68, and 0.59, while average SE scores were 0.82, 0.78, and 0.85, respectively, indicating higher SE than PTE.

This suggests that PTE contributes more to the decrease in OTE than SE, highlighting disparities in production technologies between plants. These disparities lead to variations in maintenance costs and eco-feed production per unit of food waste, causing significant differences in PTE and OTE across plants.

Moreover, the potential increase in eco-feed production per plant was 3,433 tonnes for the dry method, 12,981 tonnes for the liquid method, and 335 tonnes for the fermentation method. Additionally, based on these potential increases, the estimated sales increase per plant for eco-feed was approximately 100 million JPY for the dry method, 120 million JPY for the liquid method, and 9.3 million JPY for the fermentation method. Improving efficiency could further enhance eco-feed

production and sales.

This study revealed the increase potential for the eco-feed production and its sales in inefficient plants. We also offered guidelines on whether to enhance production technology or production scale to improve the productivity of inefficient plants. Consequently, inefficient plants should seek inspiration from efficient reference plants and make improvements in either production technology or scale to boost production efficiency. This, in turn, could contribute to increasing an elevation in Japanâ€™s feed self-sufficiency rate and a further reduction of food waste.