



The potential of banana corm-based (*Musa Paradisiaca*) instant noodles as a solution-oriented strategy for implementing a circular economy for sustainable prosperity

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ABSTRACT

Background: The accumulation of agricultural waste and high dependency towards wheat imports remains a structural challenge to food security and environmental sustainability. Banana corm, an underutilized by-product rich in starch and resistant starch content, offers a strategic potential as a functional substitute for wheat in instant noodle production. The goal of this research is to bridge these gaps by formulating Miglo and simultaneously evaluating its potential to harmonize physicochemical quality with real-world economic viability. **Methods:** This mixed-method research applying a Completely Randomized Design with three substitution levels (30-50%) where physicochemical properties were analyzed descriptively while organoleptic data underwent One-Way ANOVA and Duncan's test. Socio-economic impacts were assessed through field observations to validate the circular economy's feasibility. **Findings:** The result showed that 50% substitution (T3) yielded the highest consumer acceptance, despite its decrease in carbohydrate due to resistant starch formation. Aroma and texture remained statistically unaffected, proving that high levels of substitution do not compromise overall sensory quality. Miglo implementation demonstrates economic feasibility, offering a strategic solution for agricultural waste valorization and reduced wheat dependency within a functional circular economy framework. **Conclusion:** Instant noodles made from banana corms (*Musa paradisiaca*) are an innovative circular economy strategy that is acceptable to consumers when made from a 50% wheat flour and 50% banana corm flour mixture. This strategy has a positive impact on reducing agricultural waste, strengthening food security, and improving the economic welfare of the community. **Novelty/Originality of this article:** This research provides an integrative approach bridging technical aspects and practical impacts of the circular economy model, serving as a strategic solution to ensure food sovereignty and community economic empowerment.

KEYWORDS: instant noodle; banana corm; circular economy; sustainable.

1. Introduction

The challenges faced by Indonesia in the management of its waste include a lack of attention to the issue and the accumulation of waste due to inefficient agricultural and food systems. This phenomenon is evidenced by data collected by SIPSN in 2023, which indicates that 69.9 million tons of waste remain buried in Indonesia, with the agricultural and agribusiness sectors contributing significantly to this statistic. This issue is further

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compounded by the problem of food loss and waste, which has gained significant public attention, particularly within the food processing sector. This accumulation has resulted in financial losses amounting to 213-551 trillion rupiah (equivalent to 4-5% of Indonesia's GDP) during the period spanning from 2000 to 2019. This substantial sum could have been allocated towards addressing the nutritional needs of 61-125 million individuals in Indonesia. This condition places the issue of food waste management in a more serious position.

Bananas are the most extensively cultivated fruit commodity in Indonesia (Yanuartono et al., 2020), with a documented yield of 9.34 million tons in 2023. This phenomenon is strategically leveraged by economic actors to maximize profits, particularly within the banana processing sector, which contributes significantly to national fruit exports, accounting for 11.62% of total fruit exports with an export value of USD 11.15 million (Aurelia et al., 2022). Nevertheless, the linear economic approach persists in its dominance over the majority of industries, particularly the food industry. In accordance with the "take-use-dispose" paradigm, industry actors demonstrate a reluctance to employ waste or by-products from banana processing, thereby giving rise to substantial quantities of discarded materials, including banana corms.

Due to their high starch content of 78% (Ihsanti et al., 2024), banana corms are classified as a potential commodity and an alternative source of energy for the body, with a gross energy value of 4,288 kcal (Kupai et al., 2020). In addition to their high-quality starch, banana corms contain 12.8% resistant starch, which can improve gut microbiota function and diversity and control blood glucose levels due to its dietary fiber-like characteristics (Bohra et al., 2024). Banana corms represent 12.4% of the total biomass of banana plants (Alcudia-Aguilar et al., 2019). This suggests that Indonesia's potential banana stem availability could reach 1.15 million tons, highlighting its significant potential as a complementary or substitute ingredient in food product processing. Utilising banana corms as a raw material in flour production could help Indonesia address its ongoing dependence on wheat commodities and achieve food independence.

Wheat (*Triticum* spp.) has become a staple ingredient in Indonesian food products due to changes in consumption patterns, shifting from tubers to wheat-based products such as bread, biscuits, and instant noodles. However, Indonesia's tropical climate makes it highly dependent on wheat commodities, and the high demand is not adequately met (Alfiansyah & Marseto, 2023). In 2022, Indonesia imported 12.9 million tons of wheat (Saputra & Setyowati, 2024). This indicates the need for diversification efforts to reduce wheat imports. One such effort is processing banana corms into flour. However, the banana corm flour itself lacks gluten, a viscoelastic matrix found in dough. Therefore, incorporating it into a composite system with wheat flour can enhance the economic value and functionality of the resulting food product, which is an instant noodle.

Instant noodles have become a staple food for Indonesians from all walks of life. Data show that instant noodle consumption in Indonesia reached 14.26 billion packs in 2022 (Fahira et al., 2024). The high level of instant noodle consumption makes them a good vehicle for applying alternative flour from banana corms due to their scalability. In mass quantities, they can significantly impact the Indonesian economy by reducing dependence on wheat imports and increasing income from utilizing banana corm waste. However, optimizing the ratio of banana corm flour used in instant noodle production is necessary to produce high-functioning products without compromising sensory quality.

In response to the multifaceted challenges, this research develops a banana-corm based instant noodle, which is named Miglo. This initiative represents a strategic and concrete implementation of the circular economy model, emphasizing the integration of environmental sustainability and economic viability. Adopting an integrative approach, this study conducts a thorough analysis, extending beyond the product formulation process and physicochemical analysis to encompass a comprehensive examination of the environmental and socio-economic impacts within the study area. The objectives of this research are to validate the technical feasibility of the product while simultaneously assessing the waste valorization potential and economic viability. The findings are expected to provide an

empirical and practical basis for a sustainable food system that synergizes agricultural waste management with food security and community economic empowerment.

2. Methods

This study employs a mixed-method approach, combining laboratory experimentation with field analysis. The experimental phase utilizes a Completely Randomized Design (CRD) with three treatments and three replicates, for a total of nine units, to determine the optimal substitution of wheat flour with banana corm flour. Treatment T1 used 70% wheat flour and 30% banana corm flour, treatment T2 used 60% wheat flour and 40% banana corm flour, and treatment T3 used 50% wheat flour and 50% banana corm flour. Data analysis was conducted using two distinctive methods based on parameters that were tested. The physicochemical properties, such as carbohydrates, reducing sugar, and starch estimation, were analyzed descriptively to identify trends and characteristics of each treatment. While the organoleptic data were analyzed statistically using One-Way Analysis of Variance (ANOVA) at a 5% significance level and followed by Duncan's Multiple Range Test (DMRT), to determine significant differences in consumer acceptance. Complementing the experimental data, a socio-economic impact analysis was conducted through field observations and interviews to evaluate the feasibility of the circular economy implementation in the study area.

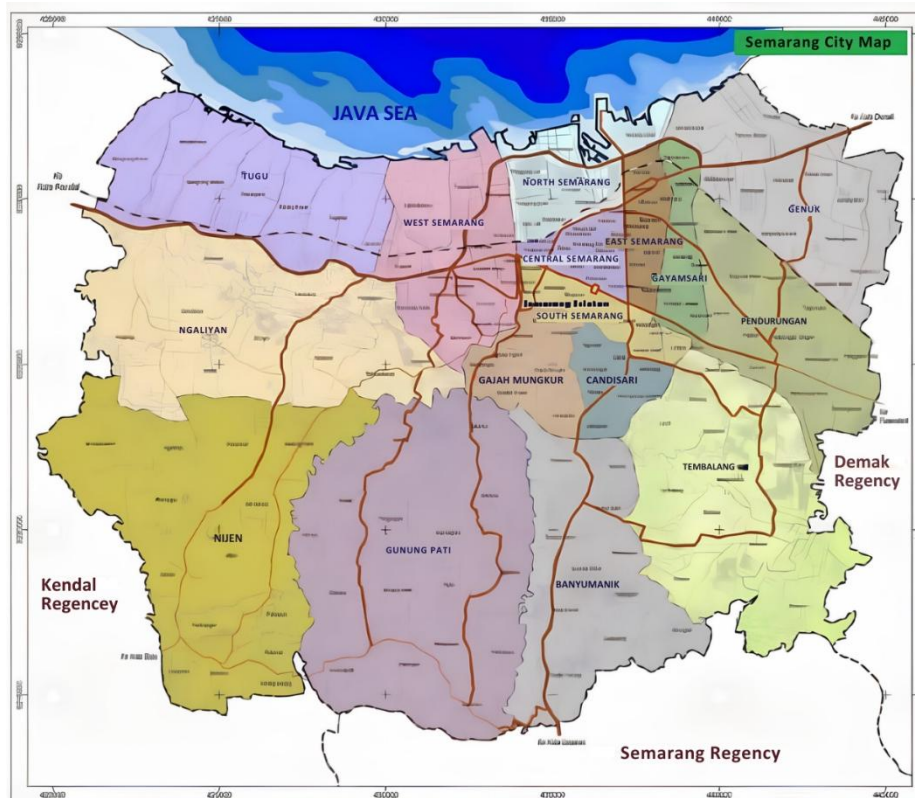


Fig. 2. Research location

The equipment used included a basin, knife, scissors, cutting board, gas stove, digital scale, spatula, boiling pot, measuring cup, noodle maker, thinwall, steamer pot, sack, mesh, spoon, tray, rolling pin, and food dehydrator. The materials used included banana corms, wheat flour, water, eggs, salt, biogas, soy sauce, and dried vegetables. In the initial steps, pre-treat the raw materials by chopping and washing the banana corms, then add water and chop until smooth. Next, strain with a filter cloth and let it stand in a container for 3 hours, then take the starch sediment at the bottom of the container. Then, place it on an oven tray and heat at 60°C for 6 hours. After that, remove the tray and mash the starch with a spoon

and sift it. Mix ingredients such as water, eggs, and salt to make noodles. Once the dough is ready, it can be flattened and cut with a noodle maker, steamed for 15 minutes, and dried at 60°C for 3 hours. The research was conducted from September to October at the Food Processing Laboratory (LFP). The reason for choosing the Food Processing Laboratory (LFP) is because this laboratory can facilitate the production of banana corm instant noodles up to the development stage. The time and place are suitable for supporting this research, with strict supervision and facilities provided by the laboratory staff.

3. Results and Discussion

3.1 Parameter explanation

Based on the organoleptic test results for Miglo products presented in Table 1, assessments were obtained for the parameters of color, aroma, texture, and taste in three treatments (T1, T2, and T3). The values shown are averages \pm standard deviations, with letter notation indicating significant differences between treatments. This treatment covers color parameters that describe the panelists' visual perception of the product's appearance, including brightness, uniformity, and color suitability with the characteristics of Miglo products. Color is an initial visual parameter that influences the panelists' interest and expectations before tasting a product (Negara et al., 2016). Attractive colors are generally associated with better product quality and freshness.

Aroma is the smell captured by the panelists' sense of smell before and while consuming the product (Lamusu, 2018). This parameter reflects the product's distinctive smell, level of freshness, and the presence or absence of foreign odors that can reduce consumer acceptance. A desirable aroma is usually distinctive, not pungent, and appropriate for the type of product. Texture describes the physical sensation of the product felt in the mouth when chewed, such as the level of hardness, crispness, softness, or smoothness (Negara et al., 2016). This parameter is greatly influenced by the composition of the ingredients and the processing method. A good texture is one that is in line with the characteristics of the product (Hasdar & Wadli, 2022). Taste is the main parameter that reflects the combination of taste sensations, including sweet, salty, savory, bitter, or sour, as well as the balance between these tastes. Taste assessment indicates the panelists' level of liking after consuming the product in terms of whether or not a product is accepted (Yasir et al., 2019).

3.2 Deviation standard

The standard deviation in the organoleptic test results shows the level of variation or diversity in the panelists' assessments of each parameter tested, namely color, aroma, texture, and taste. Standard deviation is a useful statistical tool for assessing the extent of variation from the mean (Dilla et al., 2024). The standard deviation value is obtained from the difference between each panelist's score and the average value for each treatment. The smaller the standard deviation value, the more uniform the panelists' perceptions of the product characteristics, while a larger standard deviation value indicates more diverse opinions among the panelists (Meilgaard et al., 2016). Table 1 shows that the standard deviation values for each parameter are relatively moderate, indicating that the panelists have a fairly good level of agreement in assessing Miglo products.

$$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{N}} \quad (\text{Eq. 1})$$

Although there are variations in individual assessments, these differences are still within reasonable limits in sensory testing. This shows that the products tested have relatively consistent sensory characteristics and are acceptable to most panelists. The

variation in standard deviation can also be influenced by the subjectivity of the panelists, their experience in assessing food products, and their varying sensitivity of taste and smell. Therefore, the existence of standard deviation is important to describe not only the average level of preference of the panelists, but also the stability and consistency of the panelists' perceptions of Miglo products in each treatment.

3.3 Physicochemical properties: Organoleptic test result

The analysis results show that the difference in treatment has a significant effect ($P < 0.05$) on color parameters, with treatment T3 having the highest color value (3.57 ± 0.94). In contrast, T2 only had (2.83 ± 0.75), while T1 (3.23 ± 0.63) was in the middle. This shows that treatment T3 was able to produce a product color that was more preferred by the panelists, so that the improvement in the quality of T3 became an advantage over other treatments. In terms of aroma parameters, treatment T2 (3.10 ± 0.80), treatment T1 (3.07 ± 0.91), and treatment T3 (3.00 ± 0.98). This shows that there is no significant difference ($P > 0.05$) in the color parameter tested on the panelists with the highest preference level in treatment T2. This relatively uniform aroma indicates that the main ingredients and processing methods in each treatment still retain the same odor characteristics and are acceptable to the panelists.

Table 1. Result of Miglo's organoleptic test

Sample	Color	Aroma	Texture	Taste
T1	3.23 ± 0.63^{ab}	3.07 ± 0.91^a	2.80 ± 0.89^a	2.00 ± 0.95^a
T2	2.83 ± 0.75^a	3.10 ± 0.80^a	2.97 ± 0.89^a	2.53 ± 0.63^a
T3	3.57 ± 0.94^b	3.00 ± 0.98^a	2.63 ± 0.93^a	2.80 ± 1.00^b

The texture assessment also showed no significant differences between treatments ($P > 0.05$), as indicated by the similarity of the 'a' notation given to all samples. The highest texture value was found in treatment T2 (2.97 ± 0.89). This was followed by treatment T1 (2.80 ± 0.89) and treatment T3 (2.63 ± 0.93). However, the differences in these values were still within a relatively similar range, so it can be concluded that the treatments given were not strong enough to affect the panelists' perception of texture significantly. The taste parameter showed differences between treatments. Treatment T2 (2.80 ± 1.00) was quite high compared to other treatments. Treatment T2 (2.53 ± 0.63) and treatment T1 (2.00 ± 0.95). In general, based on the parameters tested, treatment T3 showed the best performance, especially in terms of color and taste, which are important parameters. Meanwhile, aroma and texture had relatively no effect on the differences in the Miglo products that 30 panelists organoleptically tested.

The variation in organoleptic scores among treatments reflects the influence of wheat flour and banana corm flour substitution on the sensory performance of Miglo products. Color demonstrated the highest discriminative capacity, as indicated by the significant differences observed among treatments ($P < 0.05$). Treatment T3 achieved the highest color score, which can be attributed to the increased proportion of banana corm flour that enhanced non-enzymatic browning reactions during processing. The higher availability of reactive carbonyl groups from reducing sugars and amino compounds likely intensified the Maillard reaction, resulting in darker pigmentation that was perceived more favorably by the panelists.

Treatment T2 exhibited the lowest color score, suggesting that the degree of browning developed under this formulation was insufficient to produce a visually distinctive product. This result indicates that the substitution level applied in T2 had not yet reached the threshold required to promote optimal color development. Visual appearance plays a critical role in shaping consumer expectations before consumption, where darker and more uniform coloration is commonly associated with stronger flavor intensity and improved

product quality. The superior color performance of T3, therefore, likely contributed to enhanced overall sensory acceptance.

Aroma evaluation showed no significant differences among treatments ($P>0.05$), indicating that variations in banana corm flour substitution did not substantially modify the volatile compound profile of the products. The similarity in aroma scores suggests that the primary odor characteristics were preserved across formulations, likely due to comparable processing conditions and the dominant contribution of wheat flour-derived aroma compounds. The absence of undesirable odors further confirms that banana corm flour incorporation did not negatively affect aroma acceptability, which is a crucial factor for the development of food products derived from agricultural by-products.

Texture assessment also revealed no significant differences among treatments, despite minor numerical variations. This result indicates that the reduction in wheat flour content did not significantly disrupt the noodle matrix structure. Wheat flour provides gluten proteins that form a viscoelastic network, while banana corm flour contributes starch components that influence water absorption and gel formation. The interaction between these components resulted in a relatively stable textural profile across all treatments, suggesting that banana corm flour substitution up to 50% can be applied without compromising textural acceptability.

Taste evaluation exhibited clearer differentiation among treatments, with treatment T3 achieving higher preference scores compared to T1 and T2. This outcome can be associated with the formation of Maillard reaction products that contribute to more complex flavor characteristics, including savory and roasted notes. The reduction in bland starch dominance further enhanced flavor perception. Excessive substitution, however, may introduce slight aftertaste related to banana corm constituents, indicating the presence of a formulation trade-off that requires careful optimization.

Collectively, the organoleptic evaluation indicates that treatment T3 provides the most favorable sensory performance, particularly with respect to color and taste, which are primary determinants of consumer acceptance. Aroma and texture remained relatively stable across treatments, demonstrating that banana corm flour substitution does not adversely affect these attributes. These findings support the feasibility of banana corm flour as an alternative raw material for instant noodle production, provided that formulation parameters are precisely controlled.

3.4 Physicochemical properties: Carbohydrate test result

The phenol-sulfate method itself is basically used to determine the total carbohydrate content in a product. This is supported by Lam et al. (2021), who state that the implementation of this method is based on the principle of decomposing all types of carbohydrates in strong acid, namely H_2SO_4 , which is then measured colorimetrically to determine the total sugar content in the sample. Based on Table 2, treatment T1 showed the highest total carbohydrate content, namely 7.667%, followed by treatment T2 (6.707%), and treatment T3 (6.169%) with the lowest value. This shows a trend that an increase in the concentration of banana corm flour is inversely proportional to the carbohydrate content of the product, due to the role of wheat flour as the main source of carbohydrates, in the form of starch, with a content of 78.36% (Hildayanti & Pangesthi, 2017).

Table 2. Result of Miglo's carbohydrate test (phenol-sulfuric acid method)

Sample	Parameter	Unit	Result
T1	Carbohydrate (Glucose)	% Glucose	7.667
T2			6.707
T3			6.169

The total carbohydrate content in the three treatments was relatively low (<8%), indicating the occurrence of starch retrogradation during the drying process, which triggered the formation of a resistant structure that was difficult to hydrolyze with strong

acids, so that the starch content could not be read as carbohydrates in the samples. This starch fraction is better known as “Resistant Starch,” which cannot be directly read in the test results. The carbohydrate profile of Miglo products, determined using the phenol-sulfuric acid method, DNS method, and starch content calculation by difference, provides an integrated perspective on carbohydrate transformation during processing. The combined application of these analytical methods enables a comprehensive interpretation of how wheat flour substitution with banana corm flour affects both nutritional composition and sensory attributes.

Total carbohydrate analysis indicated a decreasing trend with increasing banana corm flour substitution. This pattern reflects the reduced contribution of wheat flour, which is rich in digestible starch, and the increased proportion of banana corm-derived carbohydrates that undergo structural modification during thermal processing. Drying and gelatinization processes likely promoted starch retrogradation, resulting in the formation of resistant starch fractions that were not fully hydrolyzed during analysis. Resistant starch exhibits limited digestibility and has been associated with improved glycemic response, thereby enhancing the functional value of the product.

Reducing sugar analysis using the DNS method revealed a distinct trend, highlighting dynamic carbohydrate conversion during processing. Treatment T2 exhibited the highest reducing sugar content, indicating partial starch hydrolysis during gelatinization that generated glucose and other reducing sugars. This condition represents a balanced state in which reducing sugars are sufficiently available to promote browning reactions without being excessively consumed. Treatment T3 showed a marked reduction in reducing sugar content, indicating extensive utilization of these sugars during advanced Maillard reactions, which contributed to darker coloration and intensified sensory characteristics.

Starch content estimation through calculation by difference further supports this interpretation. Treatment T1 exhibited the highest starch content, reflecting the dominance of wheat flour and the presence of amorphous gelatinized starch that contributes to chewy and elastic texture. Treatment T2 showed the lowest starch value, consistent with increased starch hydrolysis and elevated reducing sugar levels. Treatment T3 exhibited a relatively high starch value; however, this result is more closely associated with the depletion of reducing sugars during browning reactions rather than superior starch quality.

The association between carbohydrate composition and organoleptic performance was evident across treatments. Higher reducing sugar availability promoted non-enzymatic browning, which enhanced color intensity and flavor complexity, thereby increasing panelist preference. Excessive browning, however, resulted in sugar depletion and potential flavor imbalance, underscoring the importance of formulation optimization. These findings demonstrate that carbohydrate composition influences not only nutritional characteristics but also sensory acceptance.

The presence of resistant starch in Miglo products represents a significant functional advantage, particularly for consumers seeking alternative carbohydrate sources with lower digestibility. Banana corm flour utilization therefore offers dual benefits by reducing dependence on imported wheat flour and improving the functional and sustainability profile of instant noodle products. This integrated physicochemical analysis highlights the potential of Miglo as a value-added food product derived from agricultural waste valorization.

Table 3. Result of Miglo's carbohydrate test (DNS method)

Sample	Parameter	Unit	Result
T1	Carbohydrate (Glucose)	% Glucose	2.795
T2			3.202
T3			1.846

The DNS (dinitrosalicylic acid) method is used to determine the reducing sugar content (glucose, fructose, maltose) in a sample. The reaction between the DNS compound and reducing sugars forms 3-amino-5-nitrosalicylate, which has a brick-red color and can

absorb electromagnetic radiation with wavelengths up to 550 nm (Ruswandi et al., 2018). Chemically, reducing sugars are closely related to the degree of browning (non-enzymatic) that occurs in foodstuffs, particularly as a result of the Maillard reaction. According to Liu et al. (2020), the reaction between reducing sugars and proteins can form pyrrole and furan polymers, resulting in melanoidin compounds, which contribute to the brown color of food products. The test results showed a fluctuating pattern in reducing sugar content.

Treatment T1 showed a relatively low reducing sugar content (2.795), due to the dominance of wheat flour, which has a dense starch character but is very low in reducing sugar content. Treatment T2 showed an increase in reducing sugar content of $\pm 0.4\%$, accompanied by an increase in banana corm flour substitution content. Pure banana corm extract contained a total sugar content of 8.4%, with a reducing sugar content of 3.3%, similar to the content in treatment T2, indicating an optimal milling process, thus maintaining the natural nutritional profile of banana corms (Fajrih et al., 2023). Treatment T3 showed a significant decrease due to the massive Maillard reaction, resulting in the complete consumption of reducing sugars and the formation of melanoidin pigments (brown) in the product. This can be directly confirmed through experimental results, with treatment T3 showing the darkest color compared to other treatments.

Table 4. Result of Miglo's starch content (calculation by difference)

Sample	Parameter	Unit	Result
T1	Carbohydrate (Glucose)	% Starch	4.872
T2			3.505
T3			4.323

The estimation of starch content was obtained by utilizing the calculation by difference method between the two carbohydrate test results obtained. Boshagh (2021) stated that the calculation of non-reducing sugar fraction was obtained by subtracting the total sugar content from the reducing sugar content. In this study, because the raw material used was starch sediment from banana corms, it can be stated that the non-reducing sugar fraction in the sample was dominated by starch (polysaccharides). The results in Table 4 show that treatment T1 had the largest difference (4.872%), which can be interpreted as the treatment with the highest starch content. The starch content indicated by the calculation is the amorphous type of starch obtained from the gelatinization process, which directly gives a unique sensory character to treatment T1, which is relatively chewier and elastic, due to the dominance of wheat flour in the formulation. A non-linear pattern is also reflected in the data, with T2 (3.505%) showing a lower starch content value than T3 (4.323%), due to the subtraction factor applied. Treatment T2 has a lower amorphous starch content, due to the complete hydrolysis process that occurs during gelatinization, indicated by the high reducing sugar content (Table 3). Mathematically, the starch content of T3 appears to be close to that of T1, but this is more due to the minimal amount of reducing sugar remaining, as it has been used up in the Maillard reaction, rather than the high quality of the starch contained.

3.5. Product formulation

The formulation for making banana corm instant noodles consists of wheat flour, banana corm flour, eggs, and water. The study determined wheat flour and banana corm flour as independent variables, while eggs and water acted as fixed variables, with carbohydrate content and panelist preference as dependent variables in the study. Treatment T1 had a percentage of 70% wheat flour and 30% banana corm flour. Treatment T2 had a percentage of 60% wheat flour and 40% banana corm flour. Treatment T3 had a percentage of 50% wheat flour and 50% banana corm flour. This was used to determine the best composition of banana corm flour substitution for wheat flour that could be used as instant noodles.

3.6 Environmental benefits of Miglo's implementation

The use of banana corms as raw material for Miglo products has a significant environmental impact. Until now, banana corms have been considered abundant agricultural organic waste (Wisnubroto, 2023). However, they have a negative impact on the environment if left untreated (Prasetya et al., 2016). This has the potential to cause environmental pollution in the form of unpleasant odors, an increase in the population of pathogenic microorganisms, and the release of methane gas during anaerobic decomposition (Sofyan et al., 2025). By processing them, the amount of waste discarded can be utilized directly, thereby minimizing and reducing the environmental decomposition burden caused by high waste accumulation.

The environmental impact can be applied in the manufacture of Miglo products. This supports the implementation of a circular economy, where waste is no longer seen as garbage, but as raw material for a product (Marpaung et al., 2025). The conversion of banana corms into Miglo can support environmentally friendly activities through the utilization of natural resources in the form of waste, reducing dependence on conventional raw materials or non-renewable natural resources (Sufitrayati, 2025), and reducing the exploitation of new resources. This can be done through serious handling and utilization so as not to cause adverse effects on the environment (Susmiati, 2018). The conversion of banana corms into banana corm flour with a ratio of 200:1 also shows that Miglo production can increase the efficiency of banana corm waste massively and significantly in terms of quantity.

Beyond waste reduction, Miglo production also contributes to lowering the environmental footprint of food manufacturing systems. The substitution of conventional raw materials with banana corm-derived flour reduces demand for resource-intensive agricultural inputs associated with wheat-based products. This shift has the potential to decrease upstream environmental pressures related to land use, water consumption, and energy demand. Utilization of locally sourced agricultural waste further shortens supply chains, thereby reducing emissions associated with raw material transportation and logistics.

The scalability of banana corm utilization in Miglo production strengthens its role as a sustainable agro-industrial model. Large quantities of banana corm waste generated from banana cultivation can be continuously absorbed into the production system without competing with food-grade raw materials. This integration supports long-term environmental sustainability by promoting waste valorization at an industrial scale. The environmental benefits of Miglo implementation therefore extend beyond immediate waste management, positioning the product as a feasible solution for sustainable food production systems that integrate environmental responsibility with resource efficiency.

3.7 Socio-economic benefits of Miglo's implementation

This also has a real social impact, affecting targets such as banana farmers/local farmers by utilizing banana corms/waste that were previously considered waste, turning them into economically valuable raw materials and increasing managers' awareness of the importance of managing the entire harvest (Harisandi et al., 2025). Awareness of environmentally friendly products is also becoming a trend and the public's interest in this is growing (Ningrum et al., 2024). This impact can also be influenced by the creation of environmentally friendly products, which raises public awareness of the need to manage waste better. The social influence of consumer behavior towards environmentally friendly products has also increased awareness of environmental issues (Ahmadi, 2024). The production of banana corm noodles can also contribute to the creation of new jobs (Hendriyana, 2025).

The production of Miglo from banana corm flour has a positive economic impact by increasing the added value of agricultural waste. banana corms, which previously had no

economic value or were simply discarded, can now be used as an alternative raw material, creating a new source of income for farmers and communities around banana production centers. The transformation of waste into marketable food products demonstrates an increase in economic efficiency in the utilization of local resources. From the producer's perspective, banana corm flour also has the potential to reduce raw material costs, especially given the fluctuating prices of wheat flour, which is still largely dependent on imports. This substitution can increase raw material security while reducing dependence on imported foodstuffs, thereby providing long-term economic benefits for small and medium-scale producers.

Additionally, Miglo's product innovation has the potential to increase the competitiveness of local food products through product differentiation. The uniqueness of the raw material will increase its marketability and sustainability. Thus, Miglo not only serves as a food product but also as an innovative commodity with great potential. This impact shows that agricultural waste-based food innovation has great potential to be developed as a sustainable and competitive business model in the market. Therefore, this has an impact on the economy.

Beyond cost efficiency, Miglo product innovation enhances the competitiveness of local food products through differentiation based on unique raw materials and sustainability attributes. The distinctive use of banana corm flour increases product marketability while reinforcing its environmental and social value. This positioning strengthens the long-term sustainability of Miglo as both a food product and an innovative commodity within the functional and sustainable food market.

Overall, the socio-economic benefits of Miglo implementation illustrate the potential of agricultural waste-based food innovation as a sustainable business model. The integration of social empowerment, economic efficiency, and product competitiveness highlights Miglo's capacity to contribute meaningfully to community development and local economic growth. These outcomes demonstrate that waste valorization strategies can simultaneously address social challenges and enhance economic sustainability.

3.8 Circular economy implementation

The primary parameter in this case is the fluctuating price of wheat flour, which remains predominantly reliant on imports. This substitution has the potential to enhance the resilience of raw materials while reducing reliance on imported foodstuffs, thereby providing long-term economic benefits for small and medium-sized producers. The circular economy framework applied in Miglo production demonstrates an integrated approach to sustainable food systems. Conversion of banana corm waste into banana corm flour enables continuous material circulation within the production chain, reducing dependency on virgin resources. This process not only minimizes waste disposal but also enhances the efficiency of resource utilization by extending the functional value of agricultural by-products.

Implementation of this circular model also strengthens system resilience by aligning environmental sustainability with economic viability. Utilization of locally available agricultural waste supports a regenerative production cycle that reduces exposure to global supply chain disruptions. This approach illustrates how circular economy principles can be operationalized in food product innovation, providing a scalable and sustainable model for agro-industrial development. The production of instant noodles from banana corms serves as a prime example of the implementation of the circular economy concept. The utilization of banana corms as a raw material for instant noodles results in a transformation of the linear food production flow, which was previously oriented towards a "take-use-dispose" pattern, into a more sustainable circular system. Agricultural waste is converted into banana corm flour, which is then used in the Miglo production process. The implementation of this process has been demonstrated to result in a number of key environmental benefits, including the reduction of organic waste, an enhancement of resource utilization efficiency,

and a significant reduction in potential environmental pollution caused by waste decomposition in open areas.

3.9 Miglo financial projection analysis

Based on Table 5, each package produced has a cost of goods sold (COGS) of IDR 581.57. This exceptional cost efficiency is a direct result of the valorization of agricultural waste within the circular economy framework. The selling price per unit is set at IDR 3,000.00 to ensure affordability while maintaining a healthy profit margin. In order to reach the break-even point (BEP), the company needs to produce and sell at least 241 units with a value of IDR 720,843.73.

Table 5. Miglo's cost of goods sold

Description	Amount (IDR)
Raw Material Cost	298,940.00
Direct Labor Cost	50,000
Total	348,940.00
COGS per unit	581.57
Selling Price per unit	3,000.00
Profit per unit (B2C)	2,418.43
Profit per unit (Affiliator)	2,118.43
Profit per unit (Reseller)	1,968.43
Profit per unit (Distributor)	1,818.43

The target is significantly below the monthly production capacity of 600 units, indicating a safe operational buffer against market situation. Table 6 shows the projected income statement with a total net profit of IDR 1,122,160.00. The balance sheet shows total assets and liabilities balanced at IDR 10,010,450.00. The Miglo business is feasible because the profitability index calculation is more than one. In addition, the projected net profit in the Miglo business cash flow in the first year is IDR 18,984,125.00 and in the second year is IDR 33,988,925.00, representing a remarkable 79% growth that serves as a strong indicator of the business's ability to sustain profitability and scale effectively in the long run.

Table 6. Projected income statement

Description	Debit (IDR)	Credit (IDR)
B2C Sales	-	975,000.00
Affiliator Sales	-	337,500.00
Reseller Sales	-	255,000.00
Distributor Sales	-	120,000.00
Total Revenue	-	1,687,500.00
Raw Material Cost	298,940.00	-
Direct Labor Cost	50,000.00	-
Marketing Expense	136,400.00	-
Utility Expense	50,000.00	-
Administrative Expense	30,000.00	-
Total Expenses	565,340.00	-
Net Profit	-	1,122,160.00

4. Conclusions

This study examines the development of Miglo, instant noodles made from banana corm flour (*Musa paradisiaca*), as a strategic effort to reduce agricultural waste and dependence on wheat imports, while supporting the implementation of a circular economy. banana corms were chosen because they are abundant but have not been optimally utilized.

This study aims to assess the technical feasibility of the product while evaluating the environmental and socio-economic impacts of Miglo's implementation.

The research method used a mixed-method approach with a completely randomized design at three levels of banana corm flour substitution (30%, 40%, and 50%). Organoleptic test results showed that the treatment with 50% substitution provided the best acceptance level, particularly in terms of color and taste, while aroma and texture did not differ significantly between treatments. Carbohydrate analysis showed a downward trend in carbohydrates as substitution increased, which was related to the reduction in wheat flour.

This study confirms that Miglo has a positive environmental and socio-economic impact. The utilization of banana corms can reduce the accumulation of agricultural organic waste and convert it into value-added food products. From an economic perspective, Miglo has the potential to increase local community income, open up new business opportunities, and reduce dependence on imported raw materials, making Miglo a viable and sustainable model for circular economy-based food innovation.

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Author Contribution

Conceptualization, A.L.N; Abstract and Keywords, A.L.N; Introduction, A.L.N; Methodology, Y.L.I; Parameter Experience, Y.L.I; Deviation Standard, A.L.N; Physicochemical properties, Y.L.I; Organoleptic Test Result, Y.L.I. and A.L.N; Organoleptic Test Preparation, A.L.N, A.E.P., and Y.L.I; Physicochemical Properties: Carbohydrate Test Result, A.L.N; Product Formulation, A.L.N, A.E.P., and Y.L.I; Environmental and Socio-Economical Analysis, A.L.N, A.E.P., and Y.L.I; Financial Projection Analysis, Y.L.I; Conclusion, A.L.N; Document Translation, A.E.P.

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Not available.

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The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author(s) used Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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