

Production Mix Optimization in Small Manufacturing Enterprises Using Linear Programming: A Simplex Method Approach to a Packaged Snack Business

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Submitted:	Revised:	Accepted:	Published:
Aug 30, 2026	Sep 27, 2026	Oct 8, 2026	Oct 13, 2026

Abstract

Small manufacturing enterprises must balance market demand with limited production resources. Although linear programming has been increasingly applied in micro, small, and medium enterprises (MSMEs), evidence remains limited on snack-production models that jointly account for packaging materials, machine time, labor capacity, and demand constraints. This study sought to determine the optimal production mix and identify binding resource constraints at Plastik Sejahtera. A descriptive quantitative case study used data collected through direct observation, a structured interview with the business owner, and operational records from January to March 2026. The production mix was modeled using linear programming, solved through the simplex method, and verified using POM-QM for Windows. The optimal daily solution comprised 35 units of potato chips, 70 units of banana chips, and 100 units of oven-roasted peanuts, yielding a maximum modeled daily profit of Rp421,500. Machine time and labor capacity were binding constraints, while 13 kg of packaging capacity remained unused. These findings indicate that optimal production priorities depend on resource efficiency and demand limits alongside unit profit. The study illustrates how the simplex method can integrate operational constraints into production planning and provide quantitative decision support that complements small-business owners' practical experience.

Keywords: Production Mix; Linear Programming; Simplex Method; Profit Optimization; MSMEs

INTRODUCTION

Micro, small, and medium enterprises (MSMEs) occupy an important position in both developing and emerging economies because they create employment, sustain household income, and support local production networks. Their economic significance is particularly evident in Indonesia, where MSMEs account for approximately 61% of gross domestic product, absorb about 97% of the national workforce, and represent nearly 99% of business units. Despite this substantial contribution, many Indonesian MSMEs continue to operate under constraints related to productivity, access to resources, managerial capacity, and business formalization (International Monetary Fund, 2024). These challenges become particularly important in small manufacturing enterprises, where daily production decisions must be made under limited capital, materials, machinery, and labor. Improving production efficiency is therefore not merely a matter of increasing output; it is closely associated with the ability of small businesses to remain viable while making responsible use of the resources available to them.

Production planning remains one of the practical difficulties faced by small enterprises. Owners often make decisions about what and how much to produce on the basis of experience, habitual production patterns, or short-term estimates of customer demand rather than systematic quantitative analysis. Such experience is valuable because it reflects the owner's understanding of the business, yet intuition alone may not reveal the most profitable allocation when several products compete for the same limited resources. Rahma et al. (2025), for example, observed that reliance on intuition and previous experience can lead to suboptimal production outcomes in MSMEs, while Khairani et al. (2026) emphasized that restrictions on raw materials and labor time can directly affect the ability of small businesses to achieve their expected profit. Similar conditions have been reported in small food enterprises where trial-and-error production decisions make scarce-resource allocation more difficult (Dai et al., 2023). A more structured decision model is therefore needed to complement, rather than replace, the practical knowledge held by business owners.

Linear programming provides a relevant quantitative framework for addressing this type of production problem because it allows several competing production activities to be evaluated simultaneously under a set of resource constraints. The approach translates operational conditions into decision variables, an objective function, and constraint functions, making it possible to identify a production combination that provides the best

attainable result within existing capacity. The simplex method is particularly useful when a problem involves several decision variables and constraints that cannot be handled efficiently through simple graphical analysis. Its application to small businesses has shown that mathematical optimization can transform everyday information on material consumption, production time, capacity, and unit profit into a more transparent basis for decision-making (Anugerah et al., 2025; Daryani et al., 2024; Sarah et al., 2024). Such an approach is valuable for MSME owners because it connects quantitative analysis with a practical question they face every day: how should scarce resources be distributed among competing products?

Evidence from earlier studies supports the applicability of linear programming across different production settings. Sriwidadi & Agustina (2013) applied the simplex method to PD Utama Jaya Plasindo, where four plastic buckle products competed for raw materials, machine hours, labor hours, and available demand. Their findings demonstrated that production constraints could be formulated mathematically to determine a profit-maximizing product combination. Firdaus et al. (2024) later applied a similar approach to six types of spark plugs constrained by four categories of raw materials and obtained an optimal production configuration through linear programming. Anugerah et al. (2025) used linear programming to address production optimization in a tofu MSME, while Safitri et al. (2024) examined production planning for three traditional herbal products through an optimization model. Taken together, these studies show that production optimization is relevant not only to relatively structured manufacturing operations but also to smaller enterprises whose decisions are shaped by highly restricted resources.

Recent studies in food-related MSMEs provide further evidence of the practical value of the simplex method. Sarah et al. (2024) used linear programming to optimize production capacity and profit in the Alltho beverage business. Daryani et al. (2024) applied the simplex method with POM-QM to banana-chip production, while Rahma et al. (2025) demonstrated that optimizing the production mix of a traditional chip business could improve profit efficiency compared with its existing production plan. Utama & Widajanti (2024) similarly reported that linear programming could identify a more profitable production configuration for a food-processing MSME. More recent applications by Amelia et al. (2026) and Fauziyah et al. (2026) addressed production decisions in small culinary businesses facing constraints related to raw materials and processing time. Studies involving other small enterprises have reached comparable conclusions, indicating that the simplex method can provide a practical

basis for allocating scarce production resources (Damayanti & Sopiati, 2026; Khairani et al., 2026).

The growing body of research confirms the usefulness of linear programming, yet it also reveals a gap that deserves closer attention. Much of the existing literature concentrates on identifying the mathematical optimum for culinary businesses or on production systems in which raw materials constitute the dominant constraint. Other studies emphasize particular manufacturing contexts with relatively structured production systems, such as spark plugs or plastic components (Firdaus et al., 2024; Sriwidadi & Agustina, 2013). More recent work has expanded the application to production time, cost, and other operational restrictions, but the findings remain strongly dependent on the characteristics of each enterprise (Hamidah et al., 2026; Rahma et al., 2025). Consequently, evidence remains limited on how a simplex-based production-mix model can simultaneously represent packaging-material availability, machine operating time, and labor capacity in a small packaged-snack production setting. This combination of constraints is important because each resource can become a bottleneck and can change the relative attractiveness of products with different profit margins.

This issue is evident in Plastik Sejahtera, a small enterprise producing three packaged snack products: potato chips, banana chips, and oven-roasted peanuts. Each product requires a different quantity of plastic packaging material, machine-processing time, and labor input, while also generating a different unit profit. Production quantities have generally been determined from expected daily demand and the owner's previous experience. Such a practice reflects valuable experiential knowledge, but it does not provide a clear means of assessing the trade-offs that arise when the three products compete for the same limited resources. Similar resource-allocation problems have been documented in previous MSME studies, although the structure and intensity of the constraints vary considerably across businesses (Amelia et al., 2026; Fauziyah et al., 2026; Sarah et al., 2024). The operational situation of Plastik Sejahtera therefore offers an appropriate setting for examining how a mathematical model can support, rather than displace, the owner's practical judgment.

The contribution of this study lies in integrating the actual operating conditions of a small packaged-snack enterprise into a production-mix decision model that is both mathematically explicit and managerially interpretable. Rather than treating optimization solely as a computational exercise, the study connects the optimal solution with the everyday

realities of resource allocation faced by the business owner. The model considers three competing products and three operational resources plastic packaging materials, machine time, and labor capacity while incorporating the different profit contributions of each product. Manual simplex calculations are combined with POM-QM for Windows to provide computational verification and to make the resulting production recommendation easier to evaluate. This approach responds to the practical concern raised across recent optimization studies that mathematical results become more valuable to small enterprises when they can be translated into feasible production decisions (Anugerah et al., 2025; Rahma et al., 2025).

Based on these considerations, this study aims to formulate a linear programming model that represents the actual production conditions of Plastik Sejahtera, determine the optimal production mix for potato chips, banana chips, and oven-roasted peanuts using the simplex method, and examine the managerial implications of the resulting solution for the allocation of limited production resources. The analysis seeks not only to determine the maximum attainable profit but also to provide a practical basis for production planning that can be understood and applied by the business owner. By linking mathematical optimization with the operational realities of a small manufacturing enterprise, the study is expected to contribute to a more systematic, resource-conscious, and economically sustainable approach to production decision-making in MSMEs.

METHODS

This study employed a descriptive quantitative approach within a case study design. The quantitative approach was selected because the study examined measurable operational data, including production quantities, resource requirements, unit profit margins, and available production capacity, which were subsequently expressed and analyzed through a mathematical optimization model. Quantitative research provides an appropriate framework when numerical data are used to examine a problem systematically and objectively (Creswell & Creswell, 2018). The case study focused on Plastik Sejahtera, a small enterprise producing packaged snacks, because its daily production decisions involve several products competing for limited resources. The enterprise therefore served as the unit of analysis rather than as a statistical sample drawn from a larger population. This design is consistent with previous production-optimization research that applied linear programming to actual operational constraints in small enterprises (Anugerah et al., 2025). The case was examined in its real

production setting so that the resulting optimization model would reflect the conditions faced by the business owner rather than rely on hypothetical production assumptions.

Data were obtained through direct observation, a structured interview with the business owner, and internal business documentation. Direct observation was conducted to identify the production flow, processing time, and actual use of production resources. The structured interview was used to obtain information concerning machine capacity, labor availability, selling prices, production costs, unit profit margins, and estimated daily demand. These data were supported by internal records of raw-material purchases and product sales covering January–March 2026. Information obtained from the three sources was cross-checked before being incorporated into the model to reduce inconsistencies between reported and recorded operational conditions. The verified data were then converted into three decision variables: (X_1), representing the daily production quantity of potato chips; (X_2), representing banana chips; and (X_3), representing oven-roasted peanuts. The objective function was defined as maximizing daily profit, ($Z = 2,500X_1 + 2,200X_2 + 1,800X_3$), based on the respective unit profit contribution of each product.

Data analysis was conducted using linear programming with the simplex method. The optimization model incorporated the actual limitations of the enterprise, consisting of plastic packaging availability ($0.8X_1 + 0.7X_2 + 0.6X_3 \leq 150$), machine time ($3X_1 + 2.5X_2 + 2X_3 \leq 480$), and labor time ($2X_1 + 2X_2 + 1.5X_3 \leq 360$). Market-demand limits were specified as ($X_1 \leq 150$), ($X_2 \leq 120$), and ($X_3 \leq 100$), with the non-negativity requirement ($X_1, X_2, X_3 \geq 0$). The model was initially solved through manual simplex iterations to make the optimization process traceable, and the resulting solution was subsequently verified using POM-QM for Windows. This two-stage procedure was used to examine the consistency of the solution and determine the production mix that generated the highest attainable profit within the available resources. The final solution was interpreted in terms of recommended production quantities, maximum profit, and resource utilization so that the mathematical results could provide a practical basis for production decisions at Plastik Sejahtera.

RESULTS

The linear programming model was solved using the simplex method and subsequently verified using POM-QM for Windows. The optimization considered three decision variables representing the daily production quantities of potato chips (X_1), banana

chips (X_2), and oven-roasted peanuts (X_3). The solution was evaluated against the availability of plastic packaging materials, machine operating time, labor time, and the maximum daily demand for each product. The optimization process produced a feasible production mix in which all three products remained in the recommended production plan. The optimal solution was ($X_1=35$), ($X_2=70$), and ($X_3=100$), resulting in a maximum daily profit of Rp421,500.

1. Optimal Production Mix

The optimal production quantities and their respective profit contributions are presented in Table 1. The results indicate that Plastik Sejahtera should produce 35 units of potato chips, 70 units of banana chips, and 100 units of oven-roasted peanuts per day under the current resource and demand constraints.

Table 1. Optimal Production Mix and Profit Contribution

Product	Decision Variable	Optimal Quantity (units/day)	Unit Profit (Rp)	Profit Contribution (Rp)	Production Status
Potato chips	X_1	35	2,500	87,500	Produced
Banana chips	X_2	70	2,200	154,000	Produced
Oven-roasted peanuts	X_3	100	1,800	180,000	Produced
Total	—	205	—	421,500	—

As shown in Table 1, the optimal solution does not simply prioritize the product with the highest unit profit. Potato chips provide the highest profit per unit at Rp2,500, followed by banana chips at Rp2,200 and oven-roasted peanuts at Rp1,800. Nevertheless, producing the largest possible quantity of potato chips would consume machine and labor capacity that could otherwise be allocated across the other products. The simplex solution therefore identifies a combination in which the three products can coexist while producing the highest attainable profit under the specified constraints.

2. Resource Utilization and Binding Constraints

The optimal solution was further examined by comparing resource consumption with the capacity available to the enterprise. This analysis is important because an optimal production quantity alone does not indicate which operational resources are restricting further improvements. Table 2 presents the utilization and remaining capacity of each resource.

Table 2. Resource Utilization at the Optimal Production Level

Resource Constraint	Available Capacity	Resource Used	Slack	Utilization	Status
Plastic packaging material	150 kg	137 kg	13 kg	91.33%	Non-binding
Machine time	480 min	480 min	0 min	100%	Binding
Labor time	360 min	360 min	0 min	100%	Binding

The values in Table 2 demonstrate that machine time and labor time are fully utilized in the optimal solution. Machine utilization reaches 480 minutes from the available 480 minutes, while labor utilization reaches the entire 360-minute capacity. Both constraints therefore have zero slack and are classified as binding constraints. Plastic packaging material, by contrast, reaches a utilization level of 137 kg from the available 150 kg, leaving 13 kg unused. The packaging-material constraint is consequently non-binding under the optimal production plan.

3. Demand Constraints in the Optimal Solution

Market-demand restrictions were also incorporated into the optimization model to prevent the mathematical solution from recommending production quantities beyond the estimated number of units that could realistically be sold. Table 3 compares the optimal production quantities with the maximum daily demand specified for each product.

Table 3. Optimal Production Quantities and Daily Demand Limits

Product	Optimal Production	Maximum Daily Demand	Remaining Demand Capacity	Constraint Status
Potato chips	35 units	150 units	115 units	Non-binding
Banana chips	70 units	120 units	50 units	Non-binding
Oven-roasted peanuts	100 units	100 units	0 units	Binding

As presented in Table 3, potato chips are produced substantially below their maximum daily demand, leaving a difference of 115 units between the optimized production level and the demand ceiling. Banana chips similarly retain an additional demand capacity of 50 units. These differences should not be interpreted as insufficient market demand. Instead, they indicate that the existing machine and labor capacities prevent the enterprise from producing additional units even though the demand limits for these two products have not yet been reached.

A different pattern is observed for oven-roasted peanuts. The optimal production quantity reaches exactly 100 units, equal to the maximum daily demand included in the model. Its demand constraint is therefore binding. Consequently, the optimal solution is

shaped by three active restrictions: machine capacity, labor capacity, and the maximum demand for oven-roasted peanuts.

4. Interpretation of the Optimal Solution

The optimization results reveal an important feature of production planning at Plastik Sejahtera. A product with the highest unit profit does not automatically need to dominate the production mix. Potato chips generate the highest unit profit, but they also require relatively intensive use of machine and labor resources. Oven-roasted peanuts generate the lowest unit profit among the three products, yet their lower machine- and labor-time requirements allow them to remain economically relevant within the optimal combination. The model therefore balances unit profitability against the amount of scarce resources required to generate that profit.

The optimal solution also indicates that the main opportunity for increasing future production does not lie in purchasing additional plastic packaging material. Under the current production structure, 13 kg of packaging capacity remains unused. Machine time and labor capacity are the more immediate operational bottlenecks because both resources are completely utilized. From an operational perspective, an increase in machine availability or labor capacity could therefore alter the feasible production region and potentially allow the enterprise to achieve a higher level of profit. Any such expansion, however, would need to be evaluated through a new optimization scenario because changes in one capacity constraint may shift the bottleneck to another resource.

These findings provide a clearer basis for daily production planning at Plastik Sejahtera. Rather than determining production quantities solely from previous experience or the unit profit of individual products, the owner can consider how each product uses several limited resources simultaneously. Under the capacities represented in the present model, the production of 35 units of potato chips, 70 units of banana chips, and 100 units of oven-roasted peanuts represents the most profitable feasible combination, generating a maximum daily profit of Rp421,500. The result also identifies machine time and labor time as the principal operational constraints that should receive attention when the enterprise considers future capacity expansion.

DISCUSSION

The optimization results show that the most profitable production decision for Plastik Sejahtera cannot be determined solely by comparing the unit profit of individual products. Under the existing resource and demand constraints, the optimal daily production mix consists of 35 units of potato chips, 70 units of banana chips, and 100 units of oven-roasted peanuts, generating a maximum profit of Rp421,500. This combination is particularly informative because potato chips have the highest unit profit of Rp2,500, whereas oven-roasted peanuts have the lowest at Rp1,800. Nevertheless, the model does not concentrate production on potato chips. The result demonstrates that an economically preferable production mix depends on the relationship between profit contribution and the amount of scarce resources required by each product. In other words, a higher unit margin does not necessarily translate into a stronger position in the optimal production mix when the product consumes relatively more machine and labor capacity.

This finding supports the central principle of linear programming that production decisions should be evaluated simultaneously rather than product by product. Sarah et al. (2024) similarly found that optimization in a small beverage enterprise depended on the ability of the model to accommodate several production constraints within a single decision framework. Anugerah et al. (2025) also demonstrated that linear programming could identify a more efficient allocation of production resources in a tofu MSME by considering available capacity alongside the expected economic return. Comparable evidence has been reported by Amelia et al. (2026) and Fauziyah et al. (2026), whose studies of small culinary enterprises showed that the simplex method can provide a more systematic basis for determining production quantities when businesses operate under limited resources. The present findings reinforce these studies by showing that optimization is not simply a search for the product with the largest nominal margin, but a search for the combination that generates the best overall return from the resources actually available to the enterprise.

The position of oven-roasted peanuts in the optimal solution provides a particularly useful interpretation of this principle. Although this product generates the lowest profit per unit, the model recommends producing it at its full demand limit of 100 units. Its relatively moderate use of machine time and labor allows it to generate a meaningful profit contribution without consuming scarce capacity as intensively as potato chips. Oven-roasted peanuts consequently contribute Rp180,000, or approximately 42.7% of the total optimized

profit. This result differs from the initial assumption that a lower-margin product would naturally be excluded when resources were scarce. It also suggests that production specialization based exclusively on unit margins may lead to misleading managerial decisions. Firdaus et al. (2024) similarly showed that several products may remain economically relevant within an optimal manufacturing configuration when their resource requirements interact differently with the available constraints. The economic value of a product should therefore be interpreted in relation to both its contribution margin and its resource intensity.

The resource-utilization pattern provides another important explanation for the resulting production mix. Machine time reaches its full capacity of 480 minutes, while the available 360 minutes of labor are also completely utilized. Both constraints are therefore binding and constitute the immediate bottlenecks of the production system. Plastic packaging material behaves differently: only 137 kg of the available 150 kg is consumed, leaving 13 kg of slack. This pattern indicates that additional packaging material would not, by itself, enable the enterprise to increase output or profit. The result is consistent with studies emphasizing that the practical value of linear programming lies not only in identifying optimal quantities but also in revealing which resources actually restrict further production (Dully et al., 2022; Sarah et al., 2024). Identifying these bottlenecks gives the mathematical solution a clearer managerial meaning because it directs attention toward the resources that matter most for capacity improvement.

The binding constraints also carry direct implications for future business decisions. If Plastik Sejahtera intends to expand production, increasing machine availability and labor capacity deserves greater attention than purchasing additional packaging material under the current operating conditions. Machine capacity could potentially be increased through longer operating hours, improved scheduling, reduced idle time, or additional equipment, while labor capacity could be adjusted through work reallocation or additional personnel. Such decisions should nevertheless be approached carefully. Increasing one resource does not automatically guarantee a proportional increase in profit because another constraint may subsequently become binding. Linear programming is therefore most useful when treated as a decision-support process rather than as a one-time prescription. Changes in production capacity, costs, demand, or unit margins would require the model to be recalculated before a new production plan is adopted.

Market demand further shapes the interpretation of the optimal solution. Potato chips are produced at only 35 units against a maximum daily demand of 150 units, while banana chips reach 70 units against a maximum of 120 units. The difference between optimal production and demand capacity indicates that the enterprise is not constrained primarily by the market for these two products; rather, its existing machine and labor capacities prevent it from exploiting the remaining demand potential. Oven-roasted peanuts present the opposite condition because their optimal production reaches the full demand limit of 100 units. This interaction among resource availability, product profitability, and market demand adds an important dimension to the findings. Production expansion should therefore not be interpreted solely as an internal capacity issue. If machine and labor capacities are increased in the future, changes in market demand will also need to be monitored because the demand constraint may eventually become the next limiting factor.

From a practical perspective, the findings demonstrate how a relatively simple mathematical model can complement the experiential knowledge of a small-business owner. Production decisions in MSMEs are often shaped by familiarity with customers, accumulated experience, and day-to-day judgments about available resources. Such knowledge remains valuable and should not be treated as something that mathematical optimization is intended to replace. The simplex model instead provides an additional decision-making lens by making the trade-offs among products and resources more visible. This is particularly relevant for small manufacturing enterprises that may not have access to sophisticated production-planning systems. The model allows routine operational information unit profit, processing time, labor requirements, material consumption, and demand—to be translated into a production plan that can be evaluated transparently.

Theoretically, the findings strengthen the argument that production-mix optimization in small manufacturing enterprises should be understood as an interaction among contribution margins, resource intensity, capacity constraints, and market limits. Previous applications of linear programming have established its usefulness for maximizing profit in MSMEs (Amelia et al., 2026; Fauziyah et al., 2026; Utama & Widajanti, 2025). The present study extends this line of evidence by illustrating a situation in which the lowest-margin product is not eliminated but instead reaches its maximum demand level within the optimal solution. This finding cautions against reducing production optimization to a simple preference for high-margin products. The contribution of the simplex approach lies precisely

in its ability to evaluate these competing considerations simultaneously and reveal combinations that may not be intuitively obvious to decision-makers.

Several limitations should be considered when interpreting these findings. The analysis focuses on a single small manufacturing enterprise and uses operational data specific to Plastik Sejahtera; consequently, the numerical solution cannot be generalized directly to MSMEs with different cost structures, production technologies, labor arrangements, or market conditions. The model also assumes that the unit profit coefficients, resource requirements, and available capacities remain stable within the period analyzed, whereas actual business conditions may change because of fluctuations in raw-material prices, labor availability, machine performance, or customer demand. Linear programming further assumes linear relationships among the variables and does not explicitly incorporate uncertainty, product perishability, unexpected machine downtime, or changes in consumer preferences. Future studies could therefore extend the model through sensitivity analysis, integer programming, goal programming, or scenario-based optimization to examine how changes in costs, capacity, and demand affect the recommended production mix. Despite these limitations, the present model provides a transparent and practically interpretable starting point for improving resource-allocation decisions in small-scale manufacturing.

CONCLUSION

Based on the research findings and discussion, this study concludes that linear programming using the simplex method provides a systematic approach to determining the optimal production mix at Plastik Sejahtera under limited production resources. The optimal solution recommends the daily production of 35 units of potato chips, 70 units of banana chips, and 100 units of oven-roasted peanuts, generating a maximum daily profit of Rp421,500. Machine time and labor time are fully utilized at 480 and 360 minutes, respectively, making them the principal binding constraints, while 13 kg of the available plastic packaging material remains unused. The findings also show that a product with a lower unit profit should not automatically be excluded from the production plan. Oven-roasted peanuts, despite having the lowest unit profit among the three products, remain an important part of the optimal mix because of their relatively efficient use of the available resources.

These findings provide a practical basis for improving production planning in small manufacturing enterprises where business decisions are often shaped by experience and daily operational judgment. The simplex method can complement such practical knowledge by making resource trade-offs more visible and helping business owners determine feasible production priorities. For Plastik Sejahtera, future capacity improvements should primarily consider machine availability and labor capacity rather than additional packaging materials under the current production structure. The findings remain specific to the operational conditions, profit margins, resource capacities, and demand levels examined in this study. Future research could therefore incorporate sensitivity analysis, changes in market demand and production costs, additional capacity scenarios, or other optimization approaches to assess whether the recommended production mix remains economically viable under changing business conditions.

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