PARAMETER
JURNAL MATEMATIKA, STATISTIKA DAN TERAPANNYA

e-ISSN. 2829-6303
Vol 04 No 2, August 2025
Page 209-222

Implementation of Mixed Integer Programming Using The Branch and Bound Algorithm in Optimizing The Proft of a Chips Enterprise

Fadila Inka Syahfitri[1*], Fibri Rakhmawati[2]

[1,2,]Departement of Mathematics, Faculty of Science and Technology, State Islamic University of North Sumatera

[1,2,]Golf Course Road No.120, Central Village, Pancur Batu District, Deli Serdang Regency, 20353, North Sumatra, Indonesia.

E-mail Correspondence Author: *fadilainkasyahfitri.uinsu@gmail.com*

Abstract

Keripik Cinta Mas Hendro is a micro, small, and medium enterprise (MSME) operating in the snack industry, specializing in the production of various types of chips. This MSME struggles to determine the optimal production quantity due to limited resources, inconsistent raw material supply, and fluctuating market demand. This study aims to optimize the production quantity for each product variant using the Mixed Integer Programming approach with the Branch and Bound method. The Branch and Bound method were specifically chosen as it effectively handles decision variables that must be integers, which was critical in real-world production settings where fractional outputs are not feasible. The results showed that after optimization, production becomes more efficient, with allocations including: 2,100 packages of 500g Balado chips, 836 of 500g Sweet Corn, 4,500 of 500g Sweet and Spicy, 350 of 500g Seaweed, 8,527 of 1000g Original, 158 of 1000g Balado, 125 of 1000g Sweet Corn, 215 of 1000g Sweet and Spicy, 150 of 1000g Seaweed, along with 185 kg of Balado chips and 176.38 kg of Sweet and Spicy. As a result, the optimization increases profit from IDR 249,840,000 to IDR 360,791,500, reflecting a gain of IDR 110,951,500 or approximately 44.42%.

Keywords: *Branch and Bound Algorithm, Mixed Integer Programming, Optimization*

: https://doi.org/10.30598/parameterv4i2pp209-222

Submitted: May 2025
Accepted: July 2025

1. INTRODUCTION

The increase in the industrial sector in the business world is growing from time to time, so that it has a very significant impact, especially on the economy in Indonesia. This has certainly been proven by the many industries that have developed. Starting from small-scale industries to large-scale industries. Micro, Small and Medium Enterprises (MSMEs) are among the key sectors that significantly contribute to local economic development and job creation. According to information provided by the Ministry of Cooperatives and SMEs [1], MSMEs account for approximately 61% or 9,580 trillion of the national Gross Domestic Product (GDP) and employ over 97% of the workforce in Indonesia.

The food industry is one of the fastest growing sectors in today's economy. Keripik Cinta Mas Hendro, an MSME, is situated on the Medan-Banda Aceh Sumatra Highway, in Air Hitam Village, Gebang District, Langkat Regency. This business sells various variants of cassava chips and other snacks, and has its own charm by providing free food and drink services for visitors [2]. This uniqueness attracts many tourists to visit and buy souvenirs. However, as a micro, small, and medium enterprise (MSME), this business faces common challenges in managing raw material supplies, particularly in terms of availability and quality. These limitations directly affect production efficiency and hinder the ability to achieve optimal profit. Given that MSMEs like Keripik Cinta Mas Hendro play a crucial role in driving local economic growth and generating employment, improving their operational effectiveness is essential to ensure sustainability and broader economic contribution.

These problems reflect the general challenges faced by MSMEs in the midst of increasingly fierce competition. Therefore, effective strategies are needed to improve productivity and competitiveness. One crucial aspect that needs to be considered is the optimization of the production process. Several factors such as product prices, availability of raw materials, and the amount of demand greatly affect the achievement of profits. Thus, managing these factors optimally is the key to business success [3].

To improve efficiency and profit, this issue can be addressed using a linear programming approach[4]. Linear programming serves as an analytical tool to determine the best possible outcomes, such as maximizing profit or minimizing costs in a given model[5]. It is also useful for identifying suitable amounts to be produced for every item, making sure the production process runs efficiently[6]. However, many real world problems require solutions to be in integer form[7],[8], whereas linear programming typically provides solutions as real numbers or fractions. Therefore, since many real world decisions require integer based outcomes, integer programming is considered a more appropriate technique to ensure practical feasibility[9],[10].

In the case of chip production, the decision variables can be either integers or partial fractions. To overcome this, the Mixed Integer Programming (MIP) method can be used[11]. MIP allows entrepreneurs to formulate production management problems and find optimal solutions. One of the algorithms that can be used in solving MIP is the Branch and Bound algorithm [12],[13]. This algorithm will divide the variables that have not integer into sub problems and to form new constraints for these variables to obtain the best results efficiently[14],[15].

A related study by [13] explored how the MIP method was utilized to enhance profit efficiency within the D'Laundy Factory business. The study shows that method can be used to determine the most profitable combination of laundry service types by considering various operational constraints. As a result, this method is able to provide optimal solutions in production planning, thereby enabling business owners to achieve higher profitability through improved resource utilization and more accurate decision-making processes.

Furthermore, research conducted by [16] employed the branch and bound approach to maximize profit by determining the most advantageous combination of laundry services. The results indicate that Be Clean Laundry attains optimal profit when processing 53 kg of suits, 32 kg of dolls, 95 kg of blankets, 105 kg of bedcovers, 91 kg of curtains, and 805 kg of clothes, yielding Rp. 4,027,000. Similarly, the research in [12] applied this optimization technique to enhance production planning for long shirts and Ayumah tunics. Consistent with these findings, [17] implemented the same method for production scheduling of bed linens at Nikyta's business. These studies confirm the algorithm's effectiveness in determining optimal production quantities and improving profitability. which is particularly vital for MSMEs to remain resilient and competitive amid increasingly fierce market challenges.

2. RESEARCH METHODS

2.1. Type of Research

This study utilizes an applied methodology that focuses on addressing real-world problems effectively. The approach used is a quantitative approach and is carried out at MSMEs Keripik Cinta Mas Hendro on Jalan Medan-Banda Aceh, Air Hitam Village, Gebang District, Langkat Regency, North Sumatra Province. Researchers use primary data to analyze how resource allocation constraints affect the ability to determine optimal production levels, which can be addressed using linear programming techniques that are designed to allocate limited resources effectively.

As part of the modeling process, the production problem was first formulated mathematically and converted into standard form to be solved using optimization methods such as the Simplex and Branch and Bound approaches.

2.2. Optimization Model

The production problem is modeled using the Mixed Integer Programming (MIP) approach, which allows for a combination of integer and non-integer decision variables. For instance, certain variables such as the number of chip packages must be represented as whole numbers, while others, such as bulk chip production in kilograms, can be expressed in fractional values. This modeling approach ensures that the production quantities accurately reflect real-world constraints where some products cannot be divided. The general structure of the model is formulated as follows:

Maximize:

$$Z = \sum_{j=1}^{n} c_j x_j + \sum_{k=1}^{p} d_k y_k \tag{1}$$

With constraints:

$$\begin{aligned} &x_j \geq 0, and\ integer\ ; \ j = 1,2,3, \dots, n; \\ &y_k \geq 0; k = 1,2,3, \dots., p \end{aligned} \tag{2}$$

Description:

Z : Objective function

c_j : Objective function parameter; $j = 1,2,3, \dots, n$

x_j : Decision variable; $j = 1,2,3, \dots, n$

a_j : Constraint function parameter; $j = 1,2,3,\ldots,n$
b_j : Right segment value; $j = 1,2,3,\ldots,n$
d_k : Objective function parameter of the decision variable (y_k)
y_k : Decision variable not necessarily an integer; $k = 8,9$
g_k : Coefficient of the decision variable (y_k) in the constraint function [13].

2.3. Branch and Bound Method

The approach developed by Land and Doig (1960) is a well-known optimization strategy that partitions the solution space into manageable segments via a structured search tree. Each resulting node is evaluated mathematically to eventually reach the most optimal solution[18][4].

2.4. Research Method

The research procedures carried out in this study are as follows:

1) Collecting research data (types of products, raw materials, raw material prices, production costs for each product, raw material inventory, sales volume, selling prices and profits for each product) at MSMEs Keripik Cinta Mas Hendro.
2) Identifying a linear program model based on research data. Then constructing some equations using Mixed Integer Programming and solving them with branching method. After that, the objective function and constraints are added to the simplex table.
3) Verifying the solution's optimality: if the computed value is an integer, the solution is considered final. However, if a fractional result appears, the process will continue to the next phase.
4) Selecting a variable with a fraction close to 0.5 with an integer for branching and creates a new bound, then creating a sub-problem branch.
5) Completing the linear program through new constraints, if the desired result is an integer return to step h, but if the result obtained is still a non-integer value return to step.
6) Observing expected variable, to verify if the solution is the most effective. If it results in a whole number after rounding, this indicates that the optimal solution has been successfully reached.
7) Selecting the best optimal solution and making conclusions

3. RESULT AND DISCUSSION

3.1. Data Collection and Processing

In the production process, Keripik Cinta Mas Hendro chips often experience various obstacles which can certainly affect business efficiency and profits. The obstacles faced include the use of raw materials and the amount of demand. Based on research, data on raw materials and demand obtained from Keripik Cinta Mas Hendro, is summarized in Table 1.

Table 1. **Raw material data for chips production**

Type of raw material	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
Cassava (kg)	1.25	1.25	1.25	1.25	1.25	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Cooking oil (ml)	0.65	0.65	0.65	0.65	0.65	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Balado seasoning (kg)	0	0.1	0	0	0	0	0.2	0	0	0	0.2	0
Sweet corn seasoning (kg)	0	0	0.1	0	0	0	0	0.2	0	0	0	0
Sweet and spicy seasoning (kg)	0	0	0	0.2	0	0	0	0	0.4	0	0	0.4
Seaweed seasoning (kg)	0	0	0	0	0.1	0	0	0	0	0.2	0	0

Source: Keripik Cinta Mas Hendro

With :

x_1= Original cassava chips, 500g package.
x_2= Balado cassava chips, 500g package.
x_3= Sweet corn cassava chips, 500g package.
x_4= Sweet and spicy cassava chips, 500g package.
x_5= Seaweed cassava chips, 500g package.
x_6= Original cassava chips, 1000g package.
x_7= Balado cassava chips, 1000g package.
x_8= Sweet corn cassava chips, 1000g package.
x_9= Sweet and spicy cassava chips, 1000g package.
x_{10}= Seaweed cassava chips, 1000g package.
x_{11}= Balado cassava chips in bulk.
x_{12}= Sweet and spicy cassava chips in bulk.

Next, **Table 2** outlines the available stock of key raw materials used in cassava chip production at Keripik Cinta Mas Hendro for the monthly. The listed materials include cassava, cooking oil, and several flavoring variants such as balado, sweet corn, sweet and spicy, and seaweed. This dataset provides a reference for managing material supply during the specified period.

Table 2. **Monthly inventory of raw materials for chips production**

No	Type of raw material	Inventory	Unit
1	Cassava	60,000	Kg
2	Cooking oil	12,000	Ml
3	Balado seasoning	285	Kg
4	Sweet corn seasoning	213	Kg
5	Sweet and spicy seasoning	1,200	Kg
6	Seaweed seasoning	105	Kg

Source: Keripik Cinta Mas Hendro

Using the monthly stock data as a reference, the MSME produces a variety of cassava chips in different sizes and flavors. **Table 3** provides an overview of the profit margin and demand volume for each product variant within the same timeframe.

Table 3. **Profit for Each Type of Chips**

No	Type of chips	Profit (IDR)	Quantity of demand	Unit
1.	Original cassava chips 500 gr	13,000	1,500	Pcs
2.	Balado cassava chips 500 gr	12,000	2,100	Pcs
3.	Sweet corn cassava chips 500 gr	10,500	836	Pcs
4.	Sweet and spicy cassava chips 500 gr	13,000	4,500	Pcs
5.	Seaweed cassava chips 500 gr	11,000	350	Pcs
6.	Original cassava chips 1000 gr	26,000	4,260	Kg
7.	Balado cassava chips 1000 gr	24,000	158	Kg
8.	Sweet corn cassava chips 1000 gr	21,000	125	Kg
9.	Sweet and spicy cassava chips 1000 gr	27,000	215	Kg
10.	Seaweed cassava chips 1000 gr	22,000	150	Kg
11.	Balado cassava chips in bulk	18,000	185	Kg
12.	Sweet and spicy cassava chips in bulk	25,000	176	Kg

Source: Keripik Cinta Mas Hendro

Mathematical model formulation is used in Mix Integer Programming research to obtain optimal results by applying the branch and bound algorithm. The model applied is a positive integer linear program that includes an objective function, constraint function, and certain restrictions in it [19].

3.2. Establishment of Objective Function

Based on Table 3, the profit-maximizing formulation for Keripik Cinta Mas Hendro can be derived as follows:

$$\begin{aligned} z = {} & 13{,}000x_1 + 12{,}000x_2 + 10{,}500x_3 + 13{,}000x_4 + 11{,}000x_5 + 26{,}000x_6 \\ & +24{,}000x_7 + 21{,}000x_8 + 27{,}000x_9 + 22{,}000x_{10} + 18{,}000x_{11} + 25{,}000x_{12} \end{aligned} \tag{3}$$

3.3. Constraint Function Formulation

The following construction is obtained

$$\begin{aligned}
& 1.25x_1 + 1.25x_2 + 1.25x_3 + 1.25x_4 + 1.25x_5 + 2.5x_6 + 2.5x_7 + 2.5x_8 + 2.5x_9 + \\
& 2.5x_{10} + 2.5x_{11} + 2.5x_{12} \le 60{,}000; \\
& 0.65x_1 + 0.65x_2 + 0.65x_3 + 0.65x_4 + 0.65x_5 + 1.25x_6 + 1.25x_7 + 1.25x_8 + \\
& 1.25x_9 + 1.25x_{10} + 1.25x_{11} + 1.25x_{12} \le 12{,}000; \\
& 0.2x_7 + 0.2x_{11} \le 285; \\
& 0.1x_3 + 0.2x_8 \le 213; \\
& 0.2x_4 + 0.4x_9 + 0.4x_{12} \le 1{,}200; \\
& 0.1x_5 + 0.2x_{10} \le 105; \\
& x_1 \ge 1{,}500; \\
& x_2 \ge 2{,}100; \\
& x_3 \ge 836; \\
& x_4 \ge 4{,}500; \\
& x_5 \ge 350; \\
& x_6 \ge 4{,}260; \\
& x_7 \ge 158; \\
& x_8 \ge 125; \\
& x_9 \ge 215; \\
& x_{10} \ge 150; \\
& x_{11} \ge 185; \\
& x_{12} \ge 176;
\end{aligned} \tag{4}$$

$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} \geq 0;$

with additional constraints $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}$ are integer value, and x_{11}, x_{12} are non-integer value

To achieve an optimal solution, the above equation will be processed using POM-QM for Windows V5 software by selecting the Linear Program Module. The steps taken in processing data with POM-QM are to enter all data formulations into the POM-QM software and then click solve to display the results of the input data. solution of the input data is shown in the following **Table 4**.

Table 4. Calculation result of linear programming solution

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}		RHS
Maximize	13,000	12,000	10,500	13,000	11,000	26,000	24,000	21,000	27,000	22,000	18,000	25,000		
Cassava	1.25	1.25	1.25	1.25	1.25	2.5	2.5	2.5	2.5	2.5	2.5	2.5	≤	60,000
Cooking oil	0.6	0.6	0.6	0.6	0.6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	≤	12,000
Balado seasoning	0	0.1	0	0	0	0	0.2	0	0	0	0.2	0	≤	285
Sweet corn seasoning	0	0	0.1	0	0	0	0	0.2	0	0	0	0	≤	213
Sweet and seasoning	0	0	0	0.2	0	0	0	0	0.4	0	0	0.4	≤	1,200
Seaweed seasoning	0	0	0	0	0.1	0	0	0	0	0.2	0	0	≤	105
Demand x_1	1	0	0	0	0	0	0	0	0	0	0	0	≥	1,500
Demand x_2	0	1	0	0	0	0	0	0	0	0	0	0	≥	2,100
Demand x_3	0	0	1	0	0	0	0	0	0	0	0	0	≥	836
Demand x_4	0	0	0	1	0	0	0	0	0	0	0	0	≥	4,500
Demand x_5	0	0	0	0	1	0	0	0	0	0	0	0	≥	350
Demand x_6	0	0	0	0	0	1	0	0	0	0	0	0	≥	4,260
Demand x_7	0	0	0	0	0	0	1	0	0	0	0	0	≥	158
Demand x_8	0	0	0	0	0	0	0	1	0	0	0	0	≥	125
Demand x_9	0	0	0	0	0	0	0	0	1	0	0	0	≥	215
Demand x_{10}	0	0	0	0	0	0	0	0	0	1	0	0	≥	150
Demand x_{11}	0	0	0	0	0	0	0	0	0	0	1	0	≥	185
Demand x_{12}	0	0	0	0	0	0	0	0	0	0	0	1	≥	176
Solution	1,500	2,100	836	4,500	350	8,527.83	158	125	215	150	185	176		360,803,600

Source :POM-QM V5

As presented in **Table 4**, it can be seen that the production results of the chip $x_1 = 1{,}500; x_2 = 2{,}100; x_3 = 836; x_4 = 4{,}500; x_5 = 350; x_6 = 8{,}527.83; x_7 = 158; x_8 = 125; x_9 = 215;\ x_{10} = 150;\ x_{11} = 185;$ and $x_{12} = 175$ with a total profit of IDR 360,803,600 was generated through the application of the simplex technique**.** However, this result does not reflect the most accurate or feasible solution. This occurs because the resulting value must be in integer form, yet variable $x_6 = 8{,}527.83$, remains a decimal. As a result, the calculation is repeated by applying a discrete optimization strategy to handle integer constraints effectively.

3.4 Solving Problem Using The Branch and Bound Algorithm

Because the variable x_6 is not yet integer, this solution is continued using the branch and bound method where the variable x_6 becomes the variable for branching, This leads to the creation of two subproblems: Sub-Problem 2 with the additional constraint $x_6 \leq 8{,}527$ and Sub-Problem 3 with the additional constraint $x_6 \geq 8{,}528$. To continue the process, the most favorable outcome is identified using the simplex procedure, as explained in the following section:

Sub-Problem 2

Maximizing profit : **Equation (3)**
Constraint : **Equation (4)**
: $x_6 \leq 8{,}527$ (New constraint)
$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} \geq 0,$
$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, integer, and\ x_{11}, x_{12}\ non\ integer.$
Solution :
$x_1 = 1{,}500; x_2 = 2{,}100; x_3 = 836; x_4 = 4{,}500.83; x_5 = 350; x_6 = 8{,}527; x_7 = 158; x_8 = 125;$ $x_9 = 215; x_{10} = 150; x_{11} = 185; x_{12} = 175$ with $Z = 360{,}792{,}800$.

Sub-Problem 3

Maximizing profit : **Equation (3)**
Constraint : **Equation (4)**
: $x_6 \geq 8{,}528$ (New constraint)
$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12} \geq 0,$
$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, integer, and\ x_{11}, x_{12}\ non\ integer.$
Solution : No feasible.

The branching procedure continues to execute until the variable obtains $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}$ is an integer value. After going through the iter process 5 times and becoming 11 sub-problems using the help of pom-qm, the branching diagaram can be seen in the following figure:

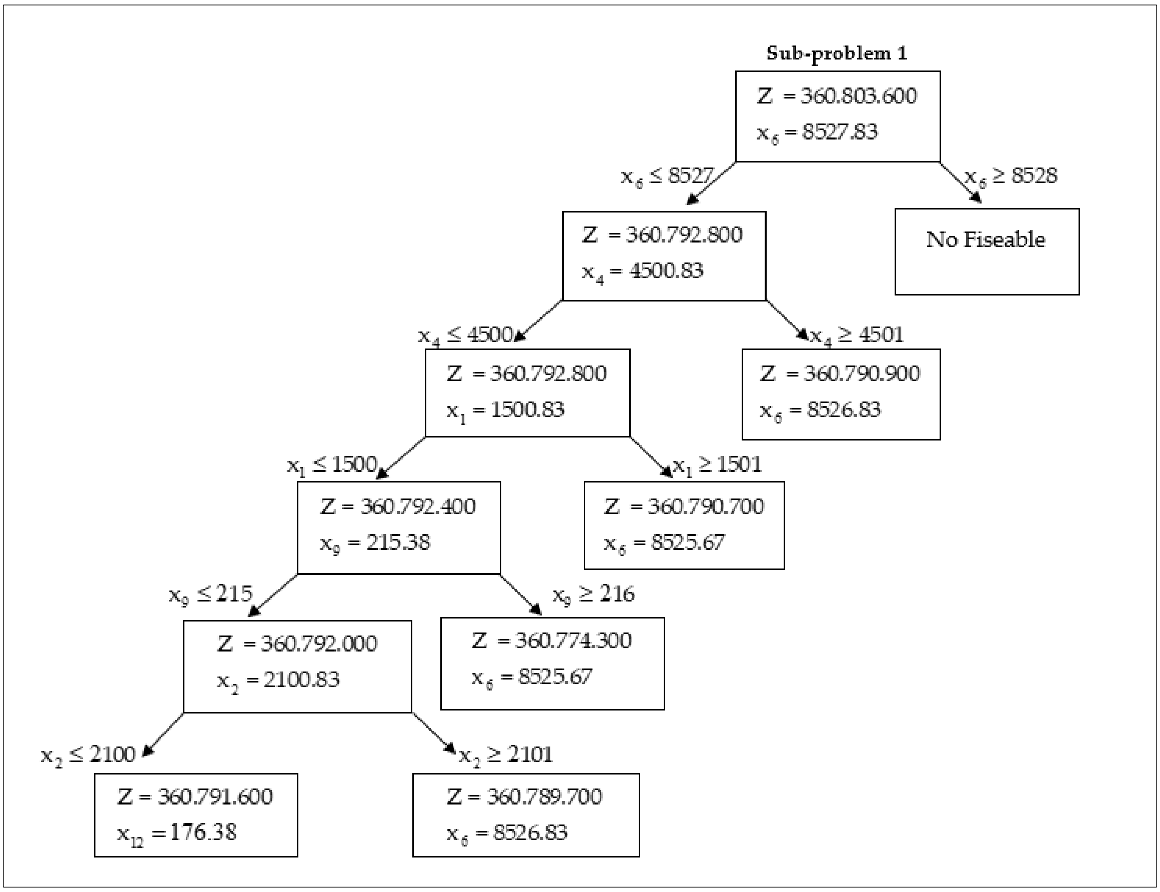

Figure 1. Branching structure diagram of the branch and bound algorithm

According to the final results achieved through an integer programming technique, specifically the branch and bound approach, each chip variant is produced at a rate follows: 1,500 packs of original chips size 500 gr; 2,100 packs of balado chips size 500 gr; 836 packs of sweet corn chips size 500 gr; 4,500 packs of sweet and spicy chips size 500 gr; 350 packs of seaweed chips size 500 gr; 8,527 packs of original chips size 1000 gr; 158 packs of balado chips size 1000 gr; 125 packs of sweet corn chips size 1000 gr; 215 packs of sweet and spicy chips size 1000 gr; 150 packs of seaweed chips size 1000 gr; 185 kg of balado flavored chips; and 176.38 kg of sweet spicy chips. All those products are estimated to give production profit of IDR 360,791,600.

This increase of IDR 110,951,500 or approximately 44.42% compared to the actual profit clearly demonstrated that the application of mathematical optimization methods in production planning had a tangible impact on improving business efficiency and profitability. Table 6 presented a comparison between the actual data from the MSMEs and the results obtained through an optimization method, including profit estimates and production quantities.

Table 6. Comparison of Factual Data and Optimal Solution

Type of chips	Factual Data		Optimal Solution		Unit
	Quantity	Profit	Quantity	Profit	
Original cassava chips 500 gr	1,500	19,500,000	1,500	19,500,000	Pcs
Balado cassava chips 500 gr	2,100	25,200,000	2,100	25,200,000	Pcs
Sweet corn cassava chips 500 gr	836	8,778,000	836	8,778,000	Pcs
Sweet and spicy cassava chips 500 gr	4,500	58,500,000	4,500	58,500,000	Pcs
Seaweed cassava chips 500 gr	350	3,850,000	350	3,850,000	Pcs

Type of chips	Factual Data		Optimal Solution		Unit
	Quantity	Profit	Quantity	Profit	
Original cassava chips 1000 gr	4,260	110,760,000	8,527	221,702,000	Pcs
Balado cassava chips 1000 gr	158	3,792,000	158	3,792,000	Pcs
Sweet corn cassava chips 1000 gr	125	2,625,000	125	2,625,000	Pcs
Sweet and spicy cassava chips 1000 gr	215	5,805,000	215	5,805,000	Pcs
Seaweed cassava chips 1000 gr	150	3,300.000	150	3,300,000	Pcs
Balado cassava chips in bulk	185	3,330,000	185	3,330,000	Kg
Sweet and spicy cassava ships in bulk	176	4,400,000	176.38	4,409,500	Kg
Total		249.840.000		360.791.500	

Referring to Table 6, there was a noticeable improvement in chip production profits following the implementation of the optimization process. Before the optimization process was carried out, the total profit obtained was only IDR 249.840.000. However, following the recalculation and revision of sales quantities across the product variants, total earnings rose to IDR 360.791.500. This increase of IDR 110.951.500 or about 44.42% shows that the application of mathematical methods in the production planning process could have a real impact on business efficiency and profitability. These results also showed that planning the right amount of production can maximize the use of resources and significantly increase sales results.

These findings were consistent with prior research by [13], which demonstrated that applying the Mixed Integer Programming method can significantly enhanced profit efficiency by identifying the most profitable combination of laundry services. Similarly, a study conducted by [20] revealed that the implementation of the branch and bound method effectively improved both production efficiency and profitability in the snack food industry.

4. CONCLUSION

According to the analysis results derived from Mixed Integer Programming, which applied a branching-based optimization algorithm using the POM-QM for Windows V5 software, this study finds that mathematical optimization can improve production planning efficiency for MSMEs, particularly in managing various chip product variants such as original, balado, sweet corn, sweet and spicy, and seaweed flavors at Keripik Cinta Mas Hendro. The model generates an optimal production mix under constraints of raw materials, operational costs, and capacity, resulting in a 44.42% profit increase or an additional IDR 110,951,500, compared to the actual condition.

These results suggest that optimization methods can serve as strategic tools in supporting more efficient production decision-making, especially for MSMEs managing multiple product types. Therefore, further research is recommended to include sensitivity analysis to assess the model's adaptability to market shifts and resource fluctuations.

ACKNOWLEDGMENTS

The authors extend their heartfelt appreciation to **Keripik Cinta Mas Hendro**, with special thanks to **Mr. Hendro (owner)** and **Mr. Rahman (manager)**, for their generous support and cooperation throughout the research. Their willingness to share valuable information and provide access to essential data played a significant role in the completion of this study. This acknowledgment is given with their full consent.

FUNDING INFORMATION

The authors declare that no external funding was received for this research. All activities related to this study were fully supported and financed by the authors themselves.

AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Fadila Inka Syahfitri	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Fibri Rakhmawati	✓	✓		✓		✓		✓		✓	✓			

C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing -Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

In accordance with ethical standards and in support of transparency in academic publishing, we, the undersigned authors, hereby declare the following:

Name	: Fadila Inka Syahfitri
Institution	: Universitas Islam Negeri Sumatera Utara
Research Title	: Implementation of Mixed Integer Programming Using the Branch and Bound Algorithm in Optimizing the Profit of a Chips MSME

Name	: Fibri Rakhmawati
Institution	: Universitas Islam Negeri Sumatera Utara
Research Title	: Implementation of Mixed Integer Programming Using the Branch and Bound Algorithm in Optimizing the Profit of a Chips MSME

We here by declare that we have **no affiliations or involvement** with any organization or entity with financial interest (such as honoraria, educational grants, participation in speakers' bureaus, memberships, employment, consultancies, stock ownership or other equity interests, and expert testimony or patent licensing arrangements), or **non-financial interests** such as personal or professional relationships, affiliations, beliefs, or knowledge related to the subject matter or materials discussed in the manuscript.

This declaration is submitted truthfully and with full awareness.

INFORMED CONSENT

We obtained informed consent from the business owners and representatives of the MSME Keripik Cinta Mas Hendro prior to conducting interviews and collecting sales data. All information provided was shared voluntarily and with full awareness and has been used solely for academic and research purposes while maintaining confidentiality.

ETHICAL APPROVAL

This research did not involve any procedures requiring ethical clearance, as it did not include experiments on human or animal subjects. The data collected through interviews with *The MSME Keripik Cinta Mas Hendro* were obtained with full consent and used solely for academic purposes, ensuring confidentiality and compliance with institutional and national research standards.

DATA AVAILABILITY

The data that supports the findings of this study are available from the corresponding author, Fadila Inka Syahfitri, upon reasonable request. Those data were obtained through direct interviews and internal sales records of *The MSME* Keripik Cinta Mas Hendro and is not publicly available due to privacy considerations and institutional restrictions.

REFERENCES

[1] Kementrian Koperasi dan UMKM, *Kerangka Acuan Kerja Pengadaan Jasa Lainnya Tenaga Pendukung Pengembangan Kewirausahaan Melalui Sinergi Dengan Dunia Usaha dan Industri*. 2024. [Online]. Available: https://lpse.kemenkopukm.go.id

[2] Eddiysahputra, "Keripik Cinta Mas Hendro, Bisnis Sambil Beramal," rri.co.id. Accessed: Nov. 15, 2024. [Online]. Available: https://www.rri.co.id/bisnis/821847/keripik-cinta-mas-hendro-bisnis-sambil-beramal

[3] M. Fausi and H. P. Lestari, "Penerapan Metode Cutting Plane Terhadap Optimisasi Jumlah Produksi," *J. Kaji. dan Terap. Mat.*, vol. 8, no. 2, pp. 85–94, 2022.

[4] P. R. THIE and G. E. KEOUGH, *AN Introductio To Linear Programming And Game Theory*, vol. 16, no. 2. Canada: Wiley, 2008.

[5] O. Riskadayanti, M. Hisjam, and Y. Yuniaristanto, "Mixed-Integer Linear Programming Model for Production Planning: A Case Study at Sawn Timber Production," *J. Tek. Ind.*, vol. 21, no. 2, pp. 163–173, 2020, doi: 10.22219/jtiumm.vol21.no2.163-173.

[6] S. N. Afiyah, M. Syaifuddin, and N. L. Aqromi, "Optimization of Teak Wood Furniture Production Using Linear Programming Method at Sumenep East Java Indonesia," *Numer. J. Mat. dan Pendidik. Mat.*, vol. 6, pp. 13–24, 2022, doi: 10.25217/numerical.v6i1.2325.

[7] V. Susanti, "Optimalisasi Produksi Tahu Menggunakan Program Linear Metode Simpleks," *MATHunesa J. Ilm. Mat.*, vol. 9, no. 2, pp. 399–406, 2021, doi: 10.26740/mathunesa.v9n2.p399-406.

[8] A. Wijaya, *Pengantar Riset Operasi*, Edisi Kedu. Jakarta: Mitra Wacana Media, 2012.

[9] A. Nurjanah and D. Idayani, "Pendekatan integer linear programming untuk mengoptimalkan produksi perencanaan kerupuk," 2024, pp. 101–107.

[10] H. A. Taha, *Operation Research An Introduction*. England: Pearson Education, 2017.

[11] A. J. Rindengan and Y. A. . Langi, *Program Linear*, no. Mi. 2018.

[12] F. Firmansah, M. R. Yuwono, and F. A. Munif, "Application of integer linear program in optimizing convection sector production results using branch and bound method," *Int. J. Appl. Math. Sci. Technol. Natl. Def.*, vol. 1, no. 1, pp. 13–20, 2023, doi:

10.58524/app.sci.def.v1i1.173.

[13] E. Safitri, S. Basriati, K. Khotimah, M. Soleh, R. A. P. Lestari, and N. Andiraja, “Penerapan Mixed Integer Programming dalam Pengoptimalan Keuntungan pada D’Laundry Factory Pekanbaru,” *J. Sains Mat. dan Stat.*, vol. 9, no. 1, p. 11, 2023, doi: 10.24014/jsms.v9i1.19755.

[14] N. Sujani, Y. H. Yogaswara, and H. B. Wibowo, “Mathematical Approach: Integer Linear Programming using Branch and Bound Method for Optimizing Defense Facility Requirements in the New Soewondo …,” vol. 42, no. 2, pp. 360–369, 2024, [Online]. Available:https://www.researchgate.net/profile/Nano-Sujani/publication/377752217_Mathematical_Approach_Integer_Linear_Programming_using_Branch_and_Bound_Method_for_Optimizing_Defense_Facility_Requirements_in_the_New_Soewondo_Airbase/links/65cb38d57900745497818509/M

[15] D. R. Khoirunnisa and Y. P. Astuti, “Analisis Sensitivitas Solusi Optimal Pada Integer Linear Programming Di Perusahaan Roti Lyly Bakery Lamongan,” *MATHunesa J. Ilm. Mat.*, vol. 11, no. 3, pp. 468–477, 2023, doi: 10.26740/mathunesa.v11n3.p468-477.

[16] B. T. Syahputra, R. S. Lubis, and H. Cipta, “Maksimasi Keuntungan Layanan Jasa Be Clean Laundry Dengan Menerapkan Metode Branch And Bound,” *Zeta - Math J.*, vol. 6, no. 2, pp. 1–5, 2021, doi: 10.31102/zeta.2021.6.2.1-5.

[17] A. Oktavia, N. Putri, I. Rina, and Z. Ikhsan, “Optimalisasi Produk Seprei di UMKM Nikyta Seprai Dengan Metode Simpleks dan Branch and Bound,” *J. Sci. Technol.*, vol. 14, no. 2013, pp. 54–65, 2024.

[18] Siswanto, *Operation Reseach Jilid 1*. Jakarta: Erlangga, 2007.

[19] A. Tantri, A. Siregar, and S. Sitepu, “Implementasi Integer Linear Programming Dengan Metode Branch And Bound Dalam Menentukan Optimasi Jumlah Produksi (Studi Kasus: Pabrik Roti Wati Bakery),” *Leibniz J. Mat.*, vol. 4, pp. 42–55, 2024.

[20] S. Hasan and Y. A. Nugroho, “Optimasi Keuntungan Produk Keripik Singkong Menggunakan Metode Branch And Bound Dan Algoritma Genetika Pada Gnp Snack,” vol. 18, no. 1, pp. 57–64, 2020.