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A Comparison of Linear and Integer Linear Programming for the Profit Optimization in Bakery Production: A Case Study at Temptlicious Enterprise

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HIGHLIGHTS

- To increase profits while trying to minimize production costs, linear programming was used to allocate production resources.
- Small bakery production is a baking-related economic activity carried out by micro-businesses
- For each type of product, a sensitivity analysis will be used to determine the upper and lower bounds, ensuring that sales are not impacted.

ABSTRACT

Nowadays, the bakery industry is widely spread and famous because it can be run by a small industry or a large industry. Seeing as bakery businesses, especially small industries prefer to allocate scarce resources through trial and error to maximize profit. As a result, the company has had difficulty allocating scarce resources, affecting gross profit and gross profit margin (GPM). As a consequence, the goals of this study were (i) to determine the total number of selected products that Templicious Enterprise should produce, (ii) to compare final results using Linear Programming (LP), Integer Linear Programming (ILP), and trial-and-error methods and (iii) to find out the limits of the maximum and minimum for each type of product using sensitivity analysis. The LP and ILP methods are calculated manually and using QM for Windows. As a result, it shows that the Templicious Enterprise should produce a total of one cycle (3 units) of standard pavlova, three cycles (24 units) of superbaby pavlova and one cycle (2 units) of personal pavlova for a total profit of RM 446.99. The result was obtained using ILP, and lastly, it shows that if prices rise, the Temptlicious Enterprise will have to raise the price of the pavlova they make to avoid making a loss.

Keywords: *Linear Programming, Integer Linear Programming, Simplex Method, Sensitivity Analysis*

INTRODUCTION

The primary objective of the majority of businesses is to generate profit. Once they do not generate a profit, they will have to close the company because profit reflects its success (Oladejo et al., 2019). There are many industries in the world, including the food industry, which was founded in the early 1900s. One of the food productions is from the bakery industry. Bakery products are made with a combination of wheat and other flour such as white whole wheat flour or bread flour or others, baking powder, sugar, icing sugar, heavy cream, milk, salt, fruits, and various essences and flavorings. There are two types of bakery products available in the bakery: dry bakery products and moist bakery products. Many businesses, including bakery enterprises prefer the trial-and-error method to allocate scarce resources in a way that maximizes profit. Thus, the company has found it difficult in allocating scarce resources. When this happens, the cost of goods sold will increase. It will affect gross profit and GPM as well. Thus, the researcher emphasizes the benefits of using the linear programming method to determine profit maximization in the enterprise is more profitable than using the trial-and-error method.

In literature, many studies have been conducted concerning optimization problems by using Linear Programming (LP) and Integer Linear Programming (ILP) as appropriate methods to solve the problems. Ailobhio et al. (2018) conducted a study to find the optimal solution to maximize profit in the Lace Baking Industry Lafia using the LP model. The solution was discovered using the R statistical software. As a result, the study concludes that the Lace restaurant should produce 1550 loaves of Family loaf and 4650 loaves of Mini loaf per month to maximize profit. Furthermore, Oladejo et al. (2019) investigated the optimization principle and its application in optimizing Landmark University Bakery production through LP. The research goal is to examine the production costs and determine the optimal profit. Next, Muda. N, and Sim. R (2015) investigated the determination of optimum values for maximizing the profit in bread production in Daily Bakery Sdn Bhd through ILP. The research goal is to maximize the total production without exceeding the available resources by formulating the best combination of all ingredients in producing different types of bread. Besides that, linear programming can be used in resource minimization studies. Resources can be anything as long as they can be saved or used optimally to produce the best results (Das et al., 2017). Meanwhile, Fauzi et al. (2019) used a goal and linear programming to investigate cost-minimized diets for UiTM Perlis students to determine the lowest cost that meets students' nutritional needs and compare the linear programming and goal programming methods for cost minimization. To solve the problem, QM for Windows was used.

However, a lot of studies have been conducted by other researchers to find the optimal solution using other relevant methods. Onasanya et al. (2020) proposed a study involving linear programming with fuzzy resources and fuzzy constraints using Fuzzy Linear Programming to optimize product mix. The goal is to make the best decisions possible in the bakery's daily operations. Furthermore, according to this study, the classical linear program only provides one viable solution, Verdegay's Model, on the other hand, offers a more robust and diverse set of options than the classic way. Meanwhile, Kumar (2019) used goal programming in bakery production to optimise the daily production of a small-scale industry. Based on the discussion, finding the optimal solution can be solved by applying many methods such as fuzzy, goal programming, and linear programming. It is important to determine the most effective and appropriate method to give an accurate solution to make the decision. This study will propose applying the linear programming methodology for optimization of the production of the bakery industry.

METHODOLOGY

The data was obtained from Temptlicious Enterprise. Three types of pavlovas were chosen as variables, and seven data sets were used: total ingredient per pavlova and ingredient stock per day, number of pavlovas per cycle and its market demand per day, number of cycles per day, baking time per cycle, packaging time per cycle, and working time. The total cost per cycle, total cost per day, profit per cycle, and profit per day were calculated using a formula.

Data analysis consists of three steps: model formulation, calculation of the solution, and finally analysis of the results. In model formulation, the decision variables and the objective function were defined as below.
X_1 = standard pavlova
X_2 = superbaby pavlova

X_3 = personal pavlova

The same objective function was used by the LP and ILP methods. However, in LP, all values for variables (X_j) can be any real number, whereas in ILP, all the values for variables (X_j) must be integers. Furthermore, both the general standard form and the linear constraints function must have linear objective functions. The difference in the objective function for both methods is shown in Table 1.

Table 1: Objective Functions for LP and ILP

Method 1: Linear Programming (LP)	**Method** 2: Integer Linear Programming (ILP)
$Max\ Z = 93.18X_1 + 94.87X_2 + 69.20X_3$ $X_j \geq 0\ \&\ \forall j \in \{1,2,3\}$	$Max\ Z = 93.18X_1 + 94.87X_2 + 69.20X_3$ $X_j \geq 0\ \&\ \forall j \in \{1,2,3\}\ \&\ X_j \in Z$

Table 2 lists the various types of pavlovas made by the Temptlicious Enterprise, as well as the ingredients required. It also shows the price per unit of the ingredients in the pavlova.

Table 2: Type of Pavlovas with Its Ingredients and the Raw Material Cost per Day

Num	**Ingredients**	**Standard** X_1	**Superbaby** X_2	**Personal** X_3	**Stock per day (kg)**	**Price per unit (RM)**
1	Egg	2	1	2	20	0.30
2	Sugar /kg	0.10	0.03	0.09	2	2.20
3	Toppings /kg	0.10	0.04	0.10	2	12.00
4	Cream /kg	0.10	0.04	0.10	1	8.00
Market Demand per day		6	24	4		

Table 3: The Total Cost of Each Cycle for Producing 3 types of Pavlovas with Its Profit per Day

	Standard X_1	**Superbaby** X_2	**Personal** X_3	**Total**
Selling price / RM	32.00	12.00	36.00	
No. of pavlova / cycle	3	8	2	
No. of cycles / day	2	3	2	
Total cost / cycle (RM)	2.82	1.13	2.80	
Total cost / day (RM)	5.65	3.38	5.60	14.62
Profit / cycle (RM)	93.18	94.87	69.20	
Profit / day (RM)	186.35	284.62	138.40	609.38
Baking time / hour	0.92	1.08	0.75	5
Packing time / hour	0.50	0.50	0.50	3
Working time / hour	1.42	1.67	1.25	8

The total cost per cycle, total cost per day, profit per cycle, and profit per day can all be calculated using Table 3. As an example, for a standard pavlova (x_1), the total cost per cycle is calculated as follows: 2 eggs times RM 0.30, 0.1 kg sugar times RM 2.2, 0.1 kg toppings times RM 12, and 0.1 kg cream times RM 8. This results in a total of RM 2.82. According to the number of ingredients and the price per unit as shown in Table 2 above, the total cost per cycle for the remaining pavlova can be determined in the same manner.

By multiplying the total cost per cycle for each pavlova by the number of cycles per day, the total cost per day is determined. For example, in this case, the total cost per day for a standard pavlova is RM 2.82 multiplied by 2 and equals RM 5.65. Thus, using the same method, the total cost per day for the remaining pavlova can be determined. Next, Pavlovas from the Temptlicious Enterprise were sold to customers for RM 36 for a personal pavlova, RM 12 for a superbaby pavlova, and RM 32 for a standard pavlova.

Therefore, total selling price times the number of pavlovas per cycle minus total cost per cycle were used to calculate the profit per cycle for each pavlova.

Next, the standard forms used in this study is $Max\ Z = 93.18X_1 + 94.87X_2 + 69.20X_3$

Subject to:

Egg : $2X_1 + X_2 + 2X_3 \leq 20$
Sugar : $0.10X_1 + 0.03X_2 + 0.09X_3 \leq 2$
Toppings : $0.10X_1 + 0.04X_2 + 0.01X_3 \leq 2$
Cream : $0.10X_1 + 0.04X_2 + 0.09X_3 \leq 1$
Baking Time : $0.92 + 1.08X_2 + 0.75X_3 \leq 5$
Packing Time : $0.50X_1 + 0.50X_2 + 0.50X_3 \leq 3$
Working Time : $1.42X_1 + 1.67X_2 + 1.25X_3 \leq 8$

Restricted to:

$3X_1 \leq 6$, $8X_2 \leq 24$ and $2X_3 \leq 4$

The sign of the inequality restrictions to LP : $X_j \geq 0\ \&\ \forall j \in \{1,2,3\}$ and ILP:$X_j \geq 0\ \&\ \forall j \in \{1,2,3\}\ \&\ X_j \in Z$

Simplex Method

The Simplex Method was then applied to solve the LP. Set up the tableau to run row operations on the Linear Programming model and determine whether a solution is optimal. The original simplex tableau utilised in this investigation is displayed in Table 4 below.

Table 4**:** Initial Simplex Tableau

	C_j	93.18	94.87	69.2	0	0	0	0	0	0	0	0	0	0	
CB_i	Basic Variable	X_1	X_2	X_3	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	Qty.
0	slack 1	2	1	2	1	0	0	0	0	0	0	0	0	0	20
0	slack 2	0.1	0.03	0.09	0	1	0	0	0	0	0	0	0	0	2
0	slack 3	0.1	0.04	0.1	0	0	1	0	0	0	0	0	0	0	2
0	slack 4	0.1	0.04	0.1	0	0	0	1	0	0	0	0	0	0	1
0	slack 5	0.92	1.08	0.75	0	0	0	0	1	0	0	0	0	0	5
0	slack 6	0.5	0.5	0.5	0	0	0	0	0	1	0	0	0	0	3
0	slack 7	1.42	1.67	1.25	0	0	0	0	0	0	1	0	0	0	8
0	slack 8	3	0	0	0	0	0	0	0	0	0	1	0	0	6
0	slack 9	0	8	0	0	0	0	0	0	0	0	0	1	0	24
0	slack 10	0	0	2	0	0	0	0	0	0	0	0	0	1	4
	Z_j	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	$C_j - Z_j$	93.18	118.87	69.2	0	0	0	0	0	0	0	0	0	0	

Where:

Z = The objective function is the optimal value (maximum, minimum)
C_j = Coefficient of profit per product package for each X_n, where $n = 1,2,3$
X_n = Decision variable to n, where $n = 1,2,3$
s_n = Slack variable to n, where $n = 1,2,3$
a_{mn} = Resource requirements for each X_n, where $n = 1,2,3$ and $m = 1,2,3$
b_m = The number of resources available, where $m = 1,2,3$

n = The number of decision variables starts from 1, 2, 3
m = The number of types of resources used start from 1, 2,3

The tableau was then solved. We ensure that the last row's values in the tableau's solution had to be greater than or equal to zero. If a variable's value is less than zero, it has not reached its optimal value. Templicious Enterprise has produced a total of two cycles (6 units) of standard pavlova, 1.54 approximately two cycles (12 units) of superbaby pavlova, and two cycles (4 units) of personal pavlova with a maximum profit of RM 470.58, according to the final results shown in Table 5 below.

Table 5: Final Table Tableau

	C_j	93.18	94.87	69.20	0	0	0	0	0	0	0	0	0	0	
CB_i	Basic Variable	X_1	X_2	X_3	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	Qty.
0	slack 1	0	0	0	1	0	0	0	−0.93	0	0	−0.38	0	−0.65	10.46
0	slack 2	0	0	0	0	1	0	0	−0.03	0	0	−0.02	0	−0.03	1.57
0	slack 3	0	0	0	0	0	1	0	−0.04	0	0	−0.02	0	−0.04	1.54
0	slack 4	0	0	0	0	0	0	1	−0.04	0	0	−0.02	0	−0.04	0.54
93.18	X_1	1	0	0	0	0	0	0	0	0	0	0.33	0	0	2.00
0	slack 6	0	0	0	0	0	0	0	−0.46	1	0	−0.02	0	−0.08	0.23
0	slack 7	0	0	0	0	0	0	0	−1.55	0	1	0	0	−0.05	0.09
0	slack 9	0	0	0	0	0	0	0	−7.41	0	0	2.27	0	2.78	11.70
94.87	X_2	0	1	0	0	0	0	0	0.93	0	0	−0.28	1	−0.35	1.54
69.20	X_3	0	0	1	0	0	0	0	0	0	0	0	0	0.50	2.00
	Z_j	93.18	94.87	69.20	0	0	0	0	87.84	0	0	4.21	0	1.66	470.58
	$C_j - Z_j$	0	0	0	0	0	0	0	−87.84	0	0	−4.21	0	−1.66	

Branch and Bound Method

Next, solved ILP using the Branch and Bound Method. The initial node of the branch and bound diagram contains the relaxed LP (LP without restrictions) solution and the rounded-down solution to find any feasible solution that meets the integer constraints for use as a lower bound. In this study, the optimal solution from relaxed LP ($Z = 470.58$) is an initial upper bound for the objective function.

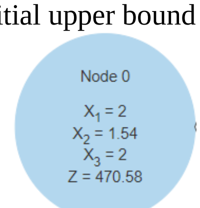

Figure 1: Initial Node

Figure 1 shows the initial node for the branch and bound method. The lower bound that we get from rounded - down solution is $X_1 = 2, X_2 = 2$ and $X_3 = 2$ with profit RM 514.5. The function of these upper bound and lower bound is to find the optimal solution since the optimal solution is always between the upper bound of the relaxed solution and a lower bound of the rounded down integer solution. Since the range of feasible solutions has been reduced to values between the upper and lower bounds, we tested the solutions within these bounds to find the best one. In order to find an ideal and workable integer solution, the problem

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was split into two subsets (or subproblems, or constraints), and this process continued until there were no more branches. It should be noted that each subset was calculated with relaxed Linear Programming. Each subset was calculated using QM for Windows. The upper bound is then set to the maximum value of the objective function at all final nodes after a final re - examination of both branches.

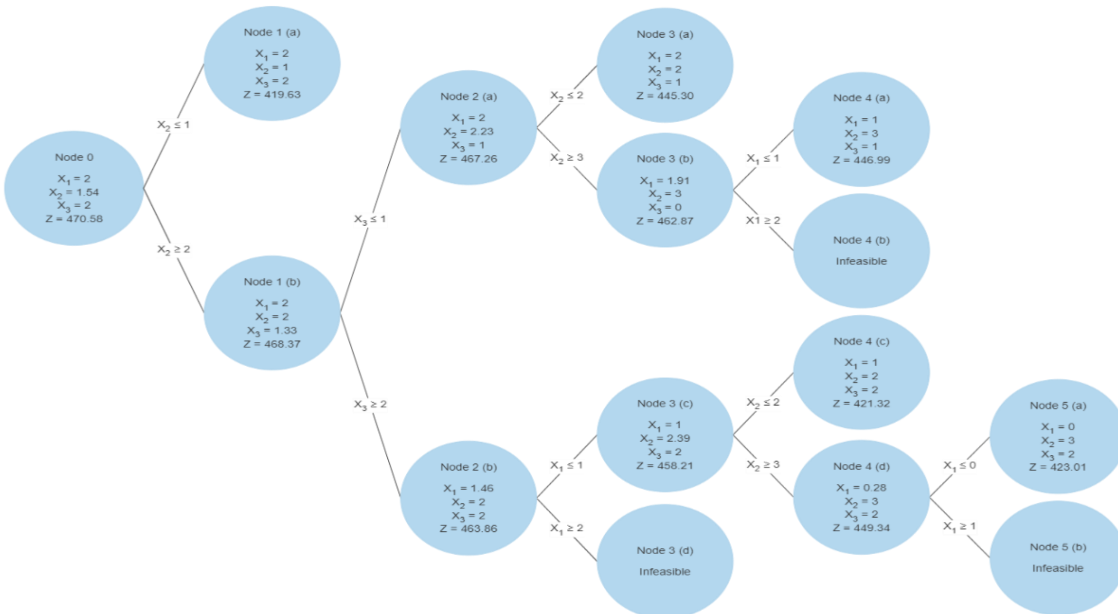

Figure 2: Branch and Bound Diagram

Based on the final result in Figure 2 above, it shows that there are five (5) integer solutions obtained in node $1(a)$, node $3(a)$, node $4(a)$, node $4(c)$ and node $5(a)$. As a result, the largest optimal value is chosen, and other nodes are terminated. The largest optimal solution is then obtained in node 4(a). In conclusion, to obtain the maximum profit while achieving the daily demand, Templicious Enterprise has issued a total of one cycle $(3$ units$)$ of standard pavlova, three cycles $(24$ units$)$ of superbaby pavlova and one cycles $(2$ units$)$ of personal pavlova with the maximum profit RM 446.99.

FINDINGS AND DISCUSSIONS

Integer Linear Programming

The results were obtained using QM for windows with three variables and ten constraints of data entry as shown in Figure 3 below.

Integer && Mixed Integer Programming Results
(untitled) Solution

Variable	Type	Value
X1	Integer	1
X2	Integer	3
X3	Integer	1
Solution value		446.99

Figure 3: ILP Summary Result

Figure 4 below, shows that to fully utilise 2 eggs, 0.1 kg of sugar, 0.1 kg of toppings, 0.1 kg of cream, 0.92 hours of baking time, 0.5 hours of packing time, and 1.42 hours of working time can produce three units (1 cycles per day × 3 pavlova per cycle). Then, to fully utilise the other ingredients for superbaby pavlova and personal pavlova, Templicious Enterprise can produce 24 units and two units per day. To avoid market supply exceeding demand, the Templicious Enterprise should reduce the number of materials used in the cycle – 1, 3 and 1 respectively, as shown in the last row in Figure 4. If the quantity is not reduced, the value cost of goods sold that supposedly decrease will increase and lead to decreasing of GPM values.

Original Problem with solution
(untitled) Solution

	X1	X2	X3		RHS
Maximize	93.18	94.87	69.2		
Constraint 1	2	1	2	<=	20
Constraint 2	.1	.03	.09	<=	2
Constraint 3	.1	.04	.1	<=	2
Constraint 4	.1	.04	.1	<=	1
Constraint 5	.92	1.08	.75	<=	5
Constraint 6	.5	.5	.5	<=	3
Constraint 7	1.42	1.67	1.25	<=	8
Constraint 8	3	0	0	<=	6
Constraint 9	0	8	0	<=	24
Constraint 10	0	0	2	<=	4
Variable type (click to set)	Integer	Integer	Integer		
Solution->	1	3	1	Optimal Z->	446.99

Figure 4: Original Problem with Solution

Next, Figure 5, shows that in level 1, if Templicious Enterprise produces superbaby pavlova (X_2) less than or equal to one cycles, two cycles of standard pavlova (X_1) and two cycles of personal pavlova (X_3) can obtain maximum profit RM 419.63, and it is an integer solution. Next, at the same level, if Templicious Enterprise produces superbaby pavlova (X_2) more than or equal to two cycles, two cycles of standard pavlova (X_1) and $1.33 \approx$ *one* cycle of personal pavlova (X_3) can obtain maximum profit RM 468.37, which is not an integer solution. Therefore, these results will examine their branches (start with $X_2 \geq 2$) again and set the upper bound since this is not an integer solution. This iteration result is a branch and bound method in table form (refer to **Figure 2** to see the tree diagram form).

Iteration Results
(untitled) Solution

Iteration	Level	Added constraint	Solution type	Solution Value	X1	X2	X3
			Optimal	446.99	1	3	1
1	0		NONinteger	470.58	2	1.54	2
2	1	X2<= 1	INTEGER	419.63	2	1	2
3	1	X2>= 2	NONinteger	468.37	2	2	1.33
4	2	X3<= 1	NONinteger	467.26	2	2.23	1
5	3	X2<= 2	INTEGER	445.3	2	2	1
6	3	X2>= 3	NONinteger	462.87	1.91	3	0
7	4	X1<= 1	INTEGER	446.99	1	3	1
8	4	X1>= 2	Infeasible				
9	2	X3>= 2	NONinteger	463.86	1.46	2	2
10	3	X1<= 1	NONinteger	458.21	1	2.39	2
11	4	X2<= 2	Suboptimal	421.32	1	2	2
12	4	X2>= 3	NONinteger	449.34	.28	3	2
13	5	X1<= 0	Suboptimal	423.01	0	3	2
14	5	X1>= 1	Infeasible				
15	3	X1>= 2	Infeasible				

Figure 5: Outputs of Optimal Solution for Maximum Profit in Templicious Enterprise

Linear Programming

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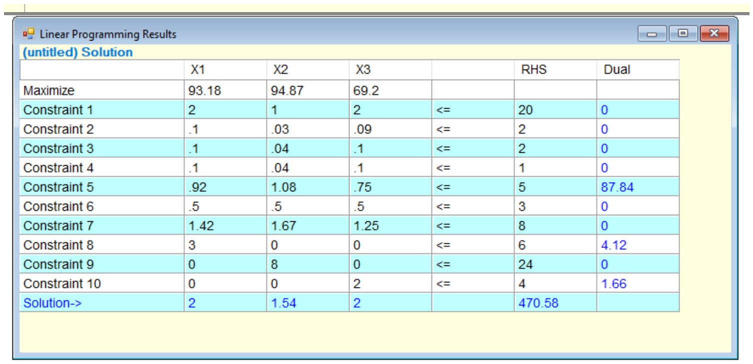
The output of LP using the QM for Windows software is shown in Figure 6 below. It shows that to fully utilise 2 eggs, 0.1 kg of sugar, 0.1 kg of toppings, 0.1 kg of cream, 0.92 hours of baking time, 0.5 hours of packing time, and 1.42 hours of working time can produce six units (2 cycles per day × 3 pavlova per cycle). Then, Templicious Enterprise may produce 12 units and 4 units per day to fully utilise the other ingredients for superbaby pavlova and personal pavlova. The Templicious Enterprise should spend less materials in the cycle - 2, 1.54 approx.2, and 2 respectively to prevent market supply from exceeding demand. If the quantity is not reduced, the supposedly reducing cost of items supplied will rise and cause a decline in GPM values.



Linear Programming Results
(untitled) Solution

	X1	X2	X3		RHS	Dual
Maximize	93.18	94.87	69.2			
Constraint 1	2	1	2	<=	20	0
Constraint 2	.1	.03	.09	<=	2	0
Constraint 3	.1	.04	.1	<=	2	0
Constraint 4	.1	.04	.1	<=	1	0
Constraint 5	.92	1.08	.75	<=	5	87.84
Constraint 6	.5	.5	.5	<=	3	0
Constraint 7	1.42	1.67	1.25	<=	8	0
Constraint 8	3	0	0	<=	6	4.12
Constraint 9	0	8	0	<=	24	0
Constraint 10	0	0	2	<=	4	1.66
Solution->	2	1.54	2		470.58	

Figure 6: Outputs of Optimal Solution of Linear Programming

Result Comparison

Table 6 below show the results for both methods used in this study.

Table 6**:** Results for Each Method Used in This Study

	Variable	Actual	LP	ILP
Profit / Day		609.38	470.58	446.99
Total Cost / Day		14.62	12.98	9.00
No. Of Cycle / Day	X_1	2	2	1
	X_2	3	1.54 ≈ 2	3
	X_3	2	2	1
Market Demand Per Day	X_1	6	6	3
	X_2	24	12.32 ≈ 12	24
	X_3	4	4	2

Based on Table 6, the trial-and-error method was used to calculate the actual value means. We can see that RM 609.38 is the highest profit per day and RM 446.99 is the lowest. The total cost per day is the same. RM 14.62 is the highest and RM 9.62 is the lowest. The study finds that the trial-and-error approach yields the highest total cost per day and the highest daily profit. Operations are being optimised by LP under some restrictions. As a result, the LP method's results are the best solution. Results from the trial-and-error method can still be applied, but there may be some problems. It's because finding the best or all feasible solutions cannot be done through trial and error. It is a technique for finding a solution to a problem. Finally, we reject the trial-and-error approach in favour of the LP and ILP approaches to find the best solution for Templicious Enterprise.

In this study, ILP is the better method for generating the best solution. First, an integer number must be used to calculate the daily cycle count. We must produce 1 or 2 cycles per day because we are unable to produce $\frac{1}{2}$ cycles per day. Any real number in LP may be used as any of the values for the variables (X_j). In contrast, all possible values for variables (X_j) in the ILP must be integers. Moreover, in LP, we rounded down the solution and rounding down might result in a suboptimal solution. That is why we used the branch and bound method to eliminate the suboptimal and infeasible solutions to find the best solution. In conclusion, it proves that ILP is the better solution for the Templicious Enterprise. ILP will produce a profit per day is RM 446.99 and the total cost per day is RM 9 with one cycle (3 units) of standard pavlova, three cycles (24 units) of superbaby pavlova and one cycle (2 units) of personal pavlova.

Sensitivity Analysis

The maximum and minimum limits for each type of pavlova that would not have an impact on its daily profits are found using a sensitivity analysis based on the results of the optimal solution. As is well known, the price will modify when market prices increase as a result of a poor economy and rising oil prices. As a result, raw material costs will indirectly increase. Therefore, analysis is conducted to evaluate whether variations in raw material prices will impact the ideal profit.

Let's assume that the overall cost of sugar is RM 2.20/kg and that it increased by RM 0.30/kg. This will increase production costs and reduce profitability. Besides, the objective function also changes to Max, $Z = 93.15X_1 + 94.87X_2 + 69.18X_3, where\ X_j \geq 0\ \&\ \forall j \in \{1,2,3\}$. Table 7 shows the comparison of the total cost per day and profit of pavlova before and after the whole price of sugar increased by RM 0.30/kg.

Table 7: Comparison of Total Cost per Day of Pavlova Before and After Sugar Price Increase

Total cost per day	Before / RM	After / RM	Increase by / RM
Standard Pavlova	5.65	5.71	0.06
Personal Pavlova	3.38	3.41	0.03
Superbaby Pavlova	5.60	5.65	0.05
Total	14.62	14.77	0.14

(untitled) Solution

	X1	X2	X3		RHS
Maximize	93.15	94.87	69.18		
Constraint 1	2	1	2	<=	20
Constraint 2	.1	.03	.09	<=	2
Constraint 3	.1	.04	.1	<=	2
Constraint 4	.1	.04	.1	<=	1
Constraint 5	.92	1.08	.75	<=	5
Constraint 6	.5	.5	.5	<=	3
Constraint 7	1.42	1.67	1.25	<=	8
Constraint 8	3	0	0	<=	6
Constraint 9	0	8	0	<=	24
Constraint 10	0	0	2	<=	4
Variable type (click to set)	Integer	Integer	Integer		
Solution->	1	3	1	Optimal Z->	446.94

Figure 7: Result ILP After Sugar Price Increase Using QM for Windows

According to Figure 7, the profit dropped from RM 446.99 (see Figure 4) to RM 446.94 (RM 0.05), while the total cost per day increased by RM 0.14 to RM 14.77 (refer Table 7). We can see that the Templicious Enterprise continues to make the same number of cycles for each pavlova every day, however. It is important to note that, in comparison to the optimal value obtained at the given cost, the gain does not decrease significantly. Usually, when prices increase, the cost of raw materials also increases and does not decrease or go back to its initial cost. The price of materials will keep rising. The Temptlicious Enterprise will therefore increase the price of the pavlova they produce if the price increases in order to prevent a loss.

CONCLUSION AND RECOMMENDATIONS

The first objective of this study is to determine the total number of selected products that should be produced to maximize profit. This objective was achieved when the Templicious Enterprise should issue a total of one cycle (3 units) of standard pavlova, three cycles (24 units) of superbaby pavlova and one cycle (2 units) of personal pavlova for a total profit of RM 446.99. This result was obtained by using ILP.
This is because ILP used the branch and bound method to eliminate the suboptimal and infeasible solution to find the best solution. It shows that the second objective is achieved. Finally, the third goal, which is to use sensitivity analysis to determine the maximum and minimum limits for each type of product, has been met. It is because we discovered that if prices rise, the Temptlicious Enterprise will have to raise the price of the pavlova they make to avoid making a loss.

The results of this study are based on the assumption that all operations in the Temptlicious Enterprise run smoothly. However, not all operations are carried out in normal circumstances. As a result, it is advised that different strategies be employed to fulfil the goals of the study. Since the Goal Programming Method is an improved method for resolving multi-objective problems and is one of the models created to handle multi-objective decision-making problems, it is one of the methods that can be used. It is a quick and simple method for cost minimization, which directly reflects the company's profit, and it allows for the simultaneous consideration of multiple objectives while the decision-making process seeks the best solution from a set of reasonable solutions by emphasising them.

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