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Optimization of Dimsum Production Profits Using the Branch and Bound Method

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Abstract: The dimsum industry in Indonesia is currently experiencing very significant development, because many businesses offer processed dim sum products for convenient consumption. The characteristics of dim sum are varied and suitable to be served as a snack. This has created an increasing number of dim sum enthusiasts, seen from the emergence of restaurants serving dim sum menus originating from China. The aim of this research is to determine the maximum profit achieved in making dim sum using the Branch and Bound technique. Using the branch and bound method because it is a mathematical model that is a development of a linear program, where all decision variables must be integers. to be a round value so that each restriction will produce a new branch. Based on the research results, it can be concluded that the optimal production level using the Branch And Bound method is IDR 19,054,950 per month. If compared with the profits before using the Branch and Bound method, the profits obtained were IDR 18,800,000. This shows that by using the Branch and Bound method, dim sum shop profits increase by IDR. 1.3% or around Rp. 254,950 per month. Sensitivity analysis shows that profits will remain at optimal conditions if the change in the objective function coefficient is smaller or equal to the objective function coefficient in the initial model.

Keywords: Branch And Bound; Dim sum Production Benefits; Optimization; Linear Programming

INTRODUCTION

Dim sum is a delicious food originating from China. Dim sum is a typical Chinese snack that is most often eaten in the morning. The proliferation of eating places serving authentic Chinese cuisine in Indonesia is proof that dim sum, even though it is a manufactured dish, is quite popular and liked there. Various ways to cook dim sum include steaming, frying, boiling, and grilling. Because sweet dim sum is more often served as a snack than as a morning meal, its flavor profile tends to be salty and savory (Taylor, 2021). The texture of dim sum changes from soft to crunchy depending on whether it is steamed or fried. For example, with the presence of Citra dim sum in Medan, now you can enjoy dim sum on the roadside or in restaurants(Magdalena, 2017).

Due to the current trend of processed dim sum products as fast food and the extraordinary popularity of the city of Medan, the reputation of this dish has increased rapidly. very popular with many people. More and more companies are choosing to offer dim sum as their product, seen from the distribution of dim sum sellers other than in Medan City on Jalan Brigjen Zein Hamid no 42 F, Jalan. Brigjen Katamso, Jalan Hm Jhoni, Jalan Cik Diitiro, Jalan Setia Budi, Jalan Mustafa, Jalan Gatot Subroto, Jalan Letda Sudjono, Jalan Tuasan, Jalan Marelan, among others, spreads in the city of Binjai which is on Jalan Soekarno Hatta, Jalan Tengku Amir Hamzah, then in Pakam on Jalan Bakaran Batu, in the city of Kabanjahe on Jalan Captain Pala Bangun, Jalan Veteran, Berastagi, in the city of Lhoksemauwe on Jalan Ramai, in the city of Rantau Prapat Jalan Kampung Baru no. 16 and Jambi city on Jalan Sergeant M Yunus no.40. Capacity planning decisions are primarily to ensure that institutions can respond to the experienced level of demand. Therefore, it is important to forecast and manage demand with good precision, to adjust capacity or take alternative actions, for example, redirecting demand to another (Sitepu et al., 2018).

In one of the dim sum businesses in the city of Medan, Dim sum Citra does not only sell one flavor of dim sum, there are several flavors of dim sum such as chicken dim sum, crab, seaweed and mozzarella. Not only dim sum and several other types of food, but also provides several drinks such as mizone, mineral water, tek bud, and bottled sosro tea. Dim sum Citra in one of the cities of Medan is ranked high among the places that young people want to visit, because it is a delicious place to relax. Therefore, the large number of visitors, especially young

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people, means that to get maximum results from their business, entrepreneurs must be good at calculating numbers so they can save costs and maximize income (Marzukoh, 2017).

One of Citra's dim sum shops in Medan City had difficulty determining how much of each type of dim sum to make. Therefore, optimizing sales is very important to achieve optimal production results. Linear programming is a mathematical paradigm that can identify better optimization solutions(Sahari & Aya, 2016).

Criteria for scheduling or scheduling model input that have been studied include: working hours (Lim, 2012) number of workers (Awadallah, 2012), as well as other special constraints. According to the number of existing or available workers (Azaiez, 2005), workers with slightly lower skills cannot take over from workers with slightly higher skills. A worker may not be placed in more than one job level position in each shift (Kim, 2014), and a number of consumers (Azaiez, 2005). There are many methods for determining schedules that can be used to complete workforce scheduling, namely the goal programming method (Downsland, 2000), the generic algorithm method (Bard, 2005), the objective programming method, and the integer linear programming method (Castillo, 2009).

The attempt to find the optimal solution for use in direct programming and subsequent generation of number selection factors is known as the Branch and Bound Approach(Sauddin et al., 2015). By creating upper and lower branches for each selected variable with partial values, this approach limits the ideal order and creates fractional numbers. Then, for each limit, only complete values will build another branch(Taha, 1997).

The use of mathematical models to optimize dimsum sales is very important considering the difficulties mentioned previously(Aminuddin, 2002).

LITERATURE REVIEW

The branch and bound method is a method for producing optimal linear program solutions that make decisions on integer variables. As the name suggests, this method limits the optimal solution that will produce a fractional number by creating an upper and lower branch for each decision variable that has a fractional value so that it has an integer value so that each decision will produce a new branch (Hartono, 2020).

In writing this research, the author will try to relate it to several scientific works previously, so that there will be a connection with the scientific work above. The scientific work the author means is as follows:

Research conducted by (Hayati, 2010)with the title Optimizing Tofu Production Using the Branch and Bound and Cutting Plane Method (Case Study: Pak Yayat Tofu Factory Jl KH. Agus Salim Kp Bulak Slamet No. 98 RT/RW 006/008 Bekasi Jaya Village, East Bekasi District, Bekasi City, West Java) in 2021. States that the aim of this research is to optimize the amount of tofu production by allocating appropriate resources to achieve maximum profits, where profits can be obtained by branch and bound method IDR 1,872,000 and cutting plane IDR 1,886,500, this means the cutting plane method is more efficient to use.

Research conducted by (Maslikhah, 2017) Optimizing Tungkal Bread Production Using the Branch and Bound Method, in 2021. The Branch and Bound Method is used to determine the optimal amount of bread production in the form of integer numbers in order to get maximum profit. The analysis results obtained show that the optimal production quantities are 2528 chocolate tungkal bread pans, 255 cheese tungkal bread pans, 375 chocolate bean tungkal bread pans, 1980 coconut tungkal bread pans, 1250 srikaya tungkal bread pans, 980 green bean tungkal bread pans, 142 pans durian tungkal bread and 80 pans of red bean tungkal bread. So the Tungkal Ani Hanim Bakery will get a profit of IDR 42,770,200. These profit results are more optimal than the amount of production carried out by the Tungkal Ani Hanim Bakery. The profits earned will increase by IDR 468,200 or 1.11% for each month.

So from the literature review, points of similarity can be found with careful research by researchers. The point of equality is that we both discuss sales profits.

METHOD

Research Place

This research was conducted at Dim sum Citra which is located on Jl. Suka Suar No. 22 in Medan, Indonesia. August 2023 marks the start and completion of this study.

Types of research

This research uses a quantitative approach based on the problems studied. Research techniques are an approach to studying a population or sample that is based on positivism. The goal of most sampling procedures is to obtain quantitative data to evaluate established hypotheses(Siswanto, 2006).

Data type and source

This research utilizes primary and secondary sources for its findings. If primary data collection is carried out through research conducted in the field, either through direct observation or interviews. At the same time, corporate accounting provides secondary data(Wijaya, 2013).

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Research Variables

The following is an example of writing the variables used in this research, namely decision variables:

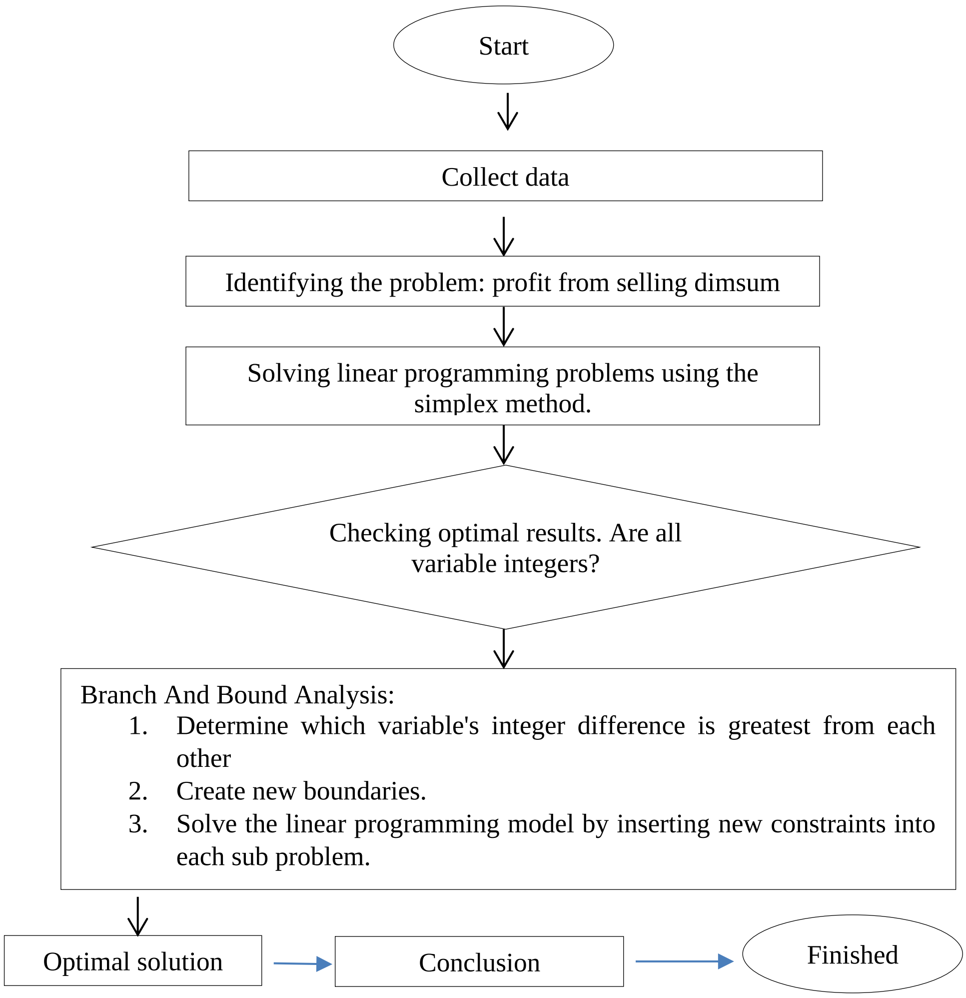
x_1 = Number of chicken dim sum
x_2= Number of shrimp dim sum
x_3 = Number of crab dim sum
x_4= Number of seaweed dim sum

Research procedures

The research procedure is as follows:

a) Interview, carried out directly asking questions to the business owner. Data obtained from interviews include the number of types of dimsum, the selling price of each type of dimsum, and the calculation of dimsum profits.
b) Observation, a method carried out by researchers directly starting from the dimsum production process. This is necessary to dig up more detailed information.
c) Data collection, collection based on monthly profit documentation Agustus
d) Process data using the Branch and Bound method
e) Make conclusions.

Flowchart



RESULT

Production Results Data

The data used includes production data for October 2023, in the form of the number of types of dim sum, the selling price of each type of dim sum, and the total profit calculation for dim sum. Data obtained from the owner of Dim sum Citra is the maximum supply of raw materials used as of October 2023.

Table 1 Production data

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Production Materials	Production needs
Chicken	110 kg
Shrimp	58 kg
Crab	55 kg
Seaweed	95 kg

Next, to calculate production capital, it is calculated based on expenditure for production needs for each dim sum variant, namely Chicken Dim sum Rp. 4,000,000/month, Shrimp Dim sum Rp. 2,825,000/month, Crab Dim sum Rp. 3,125,000/month, and seaweed dim sum amounting to IDR 2,750,000/month.

Decision Variables

The decision variables used are variables in determining production optimization, namely as follows:

x_1 = Number of chicken dim sum
x_2= Number of shrimp dim sum
x_3 = Number of crab dim sum
x_4= Number of seaweed dim sum

Objective Function

The objective function here is to optimize income generation from each dim sum production. In determining the objective function, data is needed regarding the capital each month for each dimsum variant, the selling price is 2,500/dim sum with sales averaged per month as follows:

Table 2 Average Sales

Dimsum variant	Average Sales/day	Average sales/month	Total Selling Price
Chicken dim sum	120 seeds	3600 seeds	9.000.000
Shrimp dim sum	75 seeds	2250 seeds	5.625.000
Crab dimsum	75 seeds	2250 seeds	5.625.000
Seaweed dim sum	70 seeds	2100 seeds	5.250.000

as follows :

Table 3 Profit Data on Dimsum Citra production

	Chicken dim sum	Shrimp dim sum	Crab dim sum	Seaweed dim sum
Capital (Rp)	4.000.000	2.825.000	3.125.000	2.750.000
Selling Price (Rp)	9.000.000	5.625.000	5.625.000	5.250.000
Profit (Rp)	5.000.0000	2.800.000	2.500.000	2.500.000

Profit is obtained from selling price (Rp)-capital (Rp)

Chicken dim sum = 9.000.000 – 4.000.000= 5.000.000
Shrimp dim sum = 5.625.000 - 2.825.000 = 2.800.000
Crab dim sum = 5.625.000 – 3.125.000= 2.500.000
Seaweed dim sum = 5.250.000 – 2.750.000= 2.500.000

The profit from dim sum production is shown by the coefficient of the selected variable. The objective function for dim sum production at Dim sum Citra is as follows:

$$f(x) = 5000000x_1 + 2800000x_2 + 2500000x_3 + 2500000x_4 .$$

Constraint Function

The constraints that must be considered are represented by constraint functions that have a linear relationship with the decision variables. It is these limitations or obstacles that production professionals often describe as obstacles. For example, access to basic resources. A function that has limits is called a limit function.

Specifically, the production function of Dim sum Citra dim sum, which includes its form and limitations, is as follows:

Table 4 Data on Availability of Raw Materials

Raw material	x_1	x_2	x_3	x_4	Availability
Chicken meat (kg)	95	10	2	10	3.255.000
Shrimp (kg)	5	43	2	5	1.900.000
Crab (kg)	2	2	35	2	1.700.000
Seaweed (kg)	3	1	1	75	1.200.000
Wheat flour (kg)	65	35	15	40	955.000
Starch (kg)	25	13	10	18	790.000

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Eggs (kg)	25	12	10	21	920.000
Spice	12	8	8	9	750.000
Dumpling skin (wrapper)	70	35	25	40	1.000.000
Total					12.470.000

In Table 3 you can see data on the availability of raw materials used to calculate the model constraint function. Here is a linear programming framework:

1) Stock up on Chicken meat

$$95x_1 + 10x_2 + 2x_3 + 10x_4 \leq 3255000$$

2) Shrimp Stock

$$5x_1 + 43x_2 + 2x_3 + 5x_4 \leq 1900000$$

3) Crab Stock

$$2x_1 + 2x_2 + 35x_3 + 2x_1 \leq 1700000$$

4) Supplies Seaweed

$$3x_1 + 1x_2 + 1x_3 + 75x_4 \leq 1200000$$

5) Stock up on wheat flour

$$65x_1 + 35x_2 + 15x_3 + 40x_4 \leq 955000$$

6) Stock up on starch

$$25x_1 + 13x_2 + 10x_3 + 18x_4 \leq 790000$$

7) Stock up egg

$$25x_1 + 12x_2 + 10x_3 + 21x_4 \leq 920000$$

8) Stock Up on Spices

$$12x_1 + 8x_2 + 8x_3 + 9x_4 \leq 750000$$

9) Stock up on dumpling skins

$$70x_1 + 35x_2 + 25x_3 + 40x_4 \leq 1000000$$

10) Production limitations
   a. Chicken Dim sum Production

   $$x_1 \geq 110$$

   b. Shrimp Dim sum Production

   $$x_2 \geq 58$$

   c. Crab Dim sum Production

   $$x_3 \geq 55$$

   d. Seaweed Dim sum Production

   $$x_4 \geq 95$$

Compiling a Simplex Table

For problems with multiple choice variables, the simplex approach of Linear Programming may be a useful tool. Simplex is the table technique used by this method. By plugging in all the values of the option, allowance, and excess variables, we can construct the equation into a basic table. Here, POM-QM Software is used to perform a simplex technique search for initial answers. The next image is a graphical representation of the simplex table output:

	X1	X2	X3	X4		RHS	Dual
Maximize	5000000	4500000	4800000	4500000			
Chicken meat	95	10	2	10	<=	3225000	0
Shrimp	5	43	2	5	<=	1900000	0
Crab	2	2	35	2	<=	1700000	0
Seaweed	3	1	1	75	<=	1200000	0

Flour	65	35	15	40	<=	955000	0
Starch	25	13	10	18	<=	790000	0
Egg	25	12	10	21	<=	920000	0
Spice	12	8	8	9	<=	750000	0
Dumpling skin	70	35	25	40	<=	1000000	192000
Chicken dim sum	1	0	0	0	=>	110	-8440000
Shrimp dim sum	0	1	0	0	=>	58	-2220000
Crab dim sum	0	0	1	0	=>	55	0
Seaweed dim sum	0	0	0	1	=>	95	-4140000
Solution	110	58	39439.8	95		19054950…	

Table 5 Initial solution output from POM-QM software

Table 5 shows the output of the simplex approach, which gives the following results : $x_1 = 110, x_2 = 58, x_3 = 39{,}43, x_4 = 95$. But the problem is not yet valid, because an integer answer is required. Making sure the answer is an integer is the next step, and the Branch and Bound function can help with this.

Branch and Bound Method Analysis

This technique to achieve the best linear programming solution that makes choices using integer variables is the Branch and Bound approach. Determining the upper limit (BA) and lower limit (BB) of the solution found from the simplex technique is the first step in finding integer equations.The original answer found was previously known as the upper limit (BA), .$x_1 = 110, x_2 = 58, x_3 = 39{,}43, x_4 = 95$generate a profit of (Z) = IDR 19.054.950, the profit functions as the BA, or upper limit. On the other hand, the lower limit (BB) is the final result of reducing the original solution obtained previously.$x_1 = 110, x_2 = 58, x_3 = 39, x_4 = 95$generate profit (Z) = Rp. 19.054.950 To branch out the decision variables, you must first find the upper limit (BA) and lower limit (BB). This branching process continues until optimal results are achieved.

Based on research conducted using the Branch and Bound approach, the maximum profit (Z) is IDR 38,443,000. Each type of dim sum produces 110kg of chicken, 58kg of shrimp, 39kg of crab and 95 kg of seaweed dim sum every month. See changes in your dim sum earnings before and after using the Branch and Boundary approach analysis in this handy table:

Table 6 Comparison of Benefits

No	Types of products	Company Production Amount	Total Profit	Branch and Bound Production Amount	Total Profit
1	Chicken dim sum	110	IDR. 18.800.000	110	IDR 19.054.950
2	Shrimp dim sum	58		58	
3	Crab dim sum	55		39	
4	Seaweed dim sum	95		95	

The results of using the Branch and Bound approach on Dim sum Citra production and sales data show a monthly increase of 1.3%.. The following calculation gives this result:

Profit = $19.054.950 - 18.800.000 = 254.950$

Profit Percentage = $\frac{19.054.950-18.800.000}{18.800.000} \times 100\%$

Profit Percentage = 1,3%

Sensitivity Analysis

One way to track changes in objective function coefficients and constraints is through sensitivity analysis. By examining the sensitivity of the best solution to changes in the coefficients of the objective function and constraints, sensitivity analysis provides an idea of the range of possible solutions.

Variable	Value	Reduced…	Original Variable	Lower Bound	Upper Bound
X1	110	0	5000000	-Infinity	13440000

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X2	58	0	4500000	-Infinity	6720000
X3	39439.8	0	4800000	3214286.0	-Infinity
X4	95	0	4500000	-Infinity	8640000

Table 7 displays the results of a sensitivity study conducted using the POM-QM program.

As shown in Table 7, the Cost Reduction value for all four variables is zero, which indicates that the variables are ideal and profitable for manufacturing. As a next step, the table generates a range of possible values for the objective function coefficients, with the Lower Bound and Upper Bound serving as bounds for the possible values. Maximum IDR 13,440,000 per month forx_1, maximal IDR 6.720.000 per month forx_2, maximal IDR 6.720.000 per month for x_3, the maximum is unlimited, and the maximum is IDR 8.640.000 per month for x_4, meaning the maximum profit is IDR 8.640.000.

Table 8 Output of Changes in Constraint Function

	Dual Value	Slack/Surplus	Original Variable	Lower Bound	Upper Bound
Chicken Meat	0	3134141.0	3225000	90859.5	Infinity
Shrimp	0	1817601.0	190000	82398.63	Infinity
Crab	0	318723	1700000	1381277	Infinity
Seaweed	0	1153047.0	1200000	46952.75	Infinity
Flour	0	350423	955000	604577	Infinity
Starch	0	390388	790000	399612	Infinity
Egg	0	520161	920000	399839	Infinity
Spice	0	392402.8	750000	357597.2	Infinity
Dumpling Skin	192000	0	1000000	15379.94	1227659.0
Chicken Dim sum	-8440000	0	110	0	14176
Shrimp Dim sum	-2220000	0	58	0	25088.21
Crab Dim sum	0	39384.8	55	-Infinity	39439.8
Seaweed Dim sum	0	0	0	1	0

The original value that describes the availability of raw materials in Citra's dim sum business is shown in Table 8. The ideal solution has not been exhausted, as evidenced by the slack/surplus figure which has not yet reached zero, which indicates that data consumption is less than optimal. Moreover, the use of data on the following raw materials is less than ideal: seaweed, eggs, dumpling skins, wheat flour, starch, chicken meat, shrimp, crab and seaweed. This is because raw material data is recorded if the slack/surplus value is greater than zero. Sensitivity analysis of dim sum production findings is shown on the lower and upper limit values. This shows that the value of the coefficient function has no effect on the best solution, so you can adjust the value of the coefficient depending on its value while still following the recommended lower and upper bounds.

DISCUSSIONS

In China, dim sum is a snack, dim sum is usually served as a breakfast dish. In Indonesia, dim sum is a processed product that is quite popular and has many fans, it has been proven that many restaurants have emerged serving this traditional food originating from China. Dim sum can be processed by steaming, frying, boiling and grilling. The taste characteristics of dim sum are usually salty and savory because sweet dim sum is usually not served as a breakfast dish, but as a snack. Dim sum that goes through the steaming process has a soft texture, and when fried it has a crunchy texture (Soechan, 2006).

The development of dim sum in one of the cities of Medan itself is experiencing rapid development, considering that currently many business actors are selling processed dim sum products as food for sale. The problem is that at one of the Citra dim sum outlets in Medan City, a method has not been found to determine the optimal production amount for each type of dim sum. Therefore, to maximize optimal production results, sales optimization is needed. Maximizing or minimizing the objective function depends on a number of decision variables. Furthermore, to optimize the production profits of dim sum citra, researchers used the Branch and Bound Method with the aim of finding solutions to linear programming problems because the results obtained in an effort to find solutions to optimization constraints were better and more accurate compared to other methods (Angeline, 2014).

The data used is production data in October 2023 in the form of the number of types of dim sum, the selling price of each type of dim sum, and the calculation of dimsum profits. Next, to calculate production capital, it is calculated based on expenditure for production needs for each dim sum variant, namely Chicken Dim sum Rp.

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4,000,000/month, Shrimp Dim sum Rp. 2,8250,000/month, Crab Dim sum Rp. 3,125,000/month, and seaweed dim sum amounting to IDR 2,750,000/month.

The decision variables used are variables in determining production optimization, namely as follows:

x_1 = Number of chicken dim sum
x_2 = Number of shrimp dim sum
x_3 = Number of crab dim sum
x_4= Number of seaweed dim sum.

Data regarding monthly capital for each dim sum variant, the selling price is 2,500/dim sum, the sales are averaged per month as in table 2 and in table 3 there is profit data obtained from the selling price – capital. Then the constraint function itself is referred to as an obstacle or a limitation. For example, the availability of raw materials. Simply put, a constraint function is a function that has certain limits. The functions which are the forms and limitations in dim sum production at this shop are in table 4. Arranging the equation into a simplex table is done by entering all the coefficients from the decision variable, slack variable, and surplus variable. In this case, the search for an initial solution using the simplex method was carried out with POM-QM Software. Next, the simplex table output is displayed in image form in table 5. Based on the output in table 5, from the results using the simplex method the results obtained are $x_1 = 110, x_2 = 58, x_3 = 39{,}43, x_4 = 95.95$. However, this problem is not yet valid because the solution required is an integer solution. The next step can be completed using the Branch and Bound method to ensure that the resulting solution is an integer.

The first step in finding an integer solution is to determine the Upper Limit (BA) and Lower Limit (BB) of the solution obtained using the simplex method. Upper Bound (BA) is the initial solution obtained previously. $x_1 = 110, x_2 = 58, x_3 = 39{,}43, x_4 = 9595$with a profit of ($Z$) = IDR 19,054,950 and the profit is used as the upper limit (BA). On the other hand, the lower limit (BB) is the result of rounding down from the initial solution obtained previously, , $x_1 = 110, x_2 = 58, x_3 = 39, x_4 = 95$, with profit ($Z$) = IDR 19,054,950 After the Upper Limit (BA) and Lower Limit (BB) are determined, the next step is branching the decision variables. Branching continues until the best results are obtained.

Based on research conducted using the Branch and Bound approach, the maximum profit (Z) is IDR 38,443,000. Each type of dim sum produces 110kg of chicken, 58kg of shrimp, 39kg of crab and 95 kg of seaweed dim sum every month. Based on table 6 above, this Dim sum shop shows a monthly increase of 1.3% or Rp. The following calculations give the following results:

Profit = 19,054,950-18,800,000=254,950
Profit Percentage = (19,054,950-18,800,000)/18,800,000 ×100%
Profit Percentage = 1.3%

Sensitivity analysis was carried out using the POM-QM software and the output shown in table 7 was obtained. For x_1 the maximum is IDR. 13,440,000 per month which means a maximum profit of Rp. 13,440,000, for x_2 the maximum is Rp. 6,720,000 per month which means a maximum profit of Rp. 6,720,000, for x_3 the maximum is unlimited and for x_4 the maximum is IDR. 8,640,000 per month which means a maximum profit of Rp. 8,640,000. The lower bound and upper bound values in table 8 show the results of the sensitivity analysis of dimsum production. This means that the coefficient value function does not affect the optimal solution, so it can change the coefficient value based on the value according to the recommended lower and upper bounds

CONCLUSION

To get the best monthly profit of IDR 19,054,950, research found that Dimsum Citra on Jl. Like Beacon no. 22, Medan, had to produce 684 birthday cakes using the Branch And Bound technique. The profit achieved was IDR 18,800,000 compared to the profit obtained before using the Branch and Tied approach. Following the Branch and Bound strategy, Citra dimsum shop revenue increased 1.3% or around IDR 254,950 every month. Maintaining the ideal state for profit is demonstrated by sensitivity analysis, which shows that changes in the objective function coefficients should be less than or equal to the original model's objective function coefficients.

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