WQD7011 NUMERICAL OPTIMIZATION

GROUP ASSIGNMENT

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LECTURER: DR. LIM CHEE KAU

TEAM STEP-WISERS

TITLE:

SIMPLEX OPTIMIZATION IN THE PRODUCTION OF HOMEMADE SNACKS

NO	NAME	ID
1	KRISTIAN SURYA DINATA	S2043845
2	CHAN JIE MIN	S2141167
3	TEY YI JIE	17081752
4	SITI NUR ANI YEAP	17218658

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Project Background

In the current business environment characterized by intense competition, achieving profitability and maintaining a competitive edge are essential goals for companies. To attain profitability, organizations need to optimize their production processes and resource allocation strategies. One effective approach involves the implementation of mathematical optimization techniques, such as linear programming, which enables profit maximization while considering various constraints.

Production activities are intricate networks of operations that transform inputs into finished goods. The efficiency and effectiveness of these activities directly impact a company's profit generation capabilities. Thus, managing resources such as raw materials, machinery, and labor is crucial to achieve desired output levels with minimal costs.

The simplex method, a widely utilized mathematical optimization technique, offers a systematic approach to solving linear programming problems. Its primary objective is to identify the optimal solution from a set of feasible solutions, taking into account both profit maximization and resource utilization. By iteratively evaluating extreme points, known as vertices, of the feasible region, the simplex method efficiently determines the best allocation of resources, leading to an optimal production plan.

The snack production industry can significantly benefit from the application of the simplex method. Given the wide range of snacks and various input factors involved, including ingredients, production machinery, and labour, finding the optimal combination becomes crucial for maximizing profits. Utilizing the simplex method allows snack producers to make informed decisions regarding resource allocation, production volume, and product mix, ultimately enhancing profitability.

This project focuses on the implementation of the simplex method in the context of snack production, with the objective of profit maximization. The study aims to examine the factors influencing profitability and formulate a linear programming model to optimize resource allocation. By employing the simplex method, the project aims to identify the optimal strategy for resource allocation, maximizing profits, and satisfying various production constraints. The findings from this analysis will provide valuable insights to guide decision-making and enhance the profitability of snack production in home industries.

1.2 Problem Statement

In the home snacks production industry, the challenge lies in maximizing profits through efficient resource allocation and leveraging mathematical optimization techniques. The absence of a systematic approach, such as linear programming with the simplex method, hinders the industry's ability to optimize resource utilization and achieve maximum profitability. Inadequate allocation of critical resources, including raw materials, machinery, and labour, results in suboptimal profits and limits the industry's production potential. Consequently, there is a critical need to address this problem by implementing the simplex method to optimize resource allocation and maximize profits in the home snacks production industry. This problem statement highlights two key issues: inefficient resource allocation and limited understanding of mathematical optimization techniques. The industry lacks an effective strategy for allocating resources, leading to suboptimal profit margins. Additionally, a lack of knowledge and awareness of mathematical optimization techniques, specifically the simplex method, hampers the industry's ability to maximize profits. As a result, snack producers are unable to make informed decisions on resource allocation, hindering their capacity to exploit the full potential of their production processes. To overcome these challenges, it is crucial to implement the simplex method and develop a systematic and data-driven approach to resource allocation, ultimately enabling snack producers to achieve maximum profitability in the home snacks production industry.

1.3 Objectives

The objectives for this study are as follows:

1. Develop and implement a linear programming model using the simplex method to optimize resource allocation in the home snacks production industry.

2. Maximize profitability by determining the best combination of raw materials, machinery, and labour through the application of the simplex method.

3. Evaluate the effectiveness of the optimization approach on production and profit within the snacks production process.

1.4 Literature Review

The home snacks production industry plays a vital role in meeting the growing demand for convenient and ready-to-eat snacks. To ensure long-term sustainability and competitiveness, snack producers must focus on maximizing profits through efficient resource allocation and optimization techniques. This literature review aims to explore relevant studies and research that have investigated the application of the simplex method for profit maximization in the home snacks production industry.

The simplex method, a widely recognized mathematical optimization technique, has been extensively applied to various industries for profit maximization. The simplex method provides a systematic approach to solve linear programming problems by iteratively evaluating extreme points of the feasible region. It has proven successful in optimizing resource allocation and achieving maximum profitability in manufacturing, supply chain management, and transportation sectors.

To achieve maximum profitability, snack producers need to consider various factors that affect their operations. Raw material availability, production capacity, market demand, and production costs are crucial variables that influence profit margins. Furthermore, effective utilization of machinery and labour resources is critical for profit maximization in the home snacks production industry. Optimizing the production schedule and workforce allocation using the simplex method can lead to reduced idle time, improved productivity, and ultimately, higher profits.

Several studies have evaluated the effectiveness of optimization approaches, including the simplex method, in the context of profit maximization in the snacks production industry.

In article by Uthayageetha (2017), the methodology section briefly explains the mathematical modelling of linear programming problems using decision variables and constraints. The objective is to maximize the return on different production processes. The article includes cost data for cultivating tomato and chilli crops, including various aspects such as seed cost, labour cost, fertilizers, pest control and harvesting time. The study found out that by putting the focus on the cultivation of few main crop able to maximize their profits in agriculture.

In another study by Barbieri et al. (2019) the study addresses the decision-making process of packaging section in a Brazilian e-commerce company. They implement the study by using a linear programming model using the simplex method to maximize the company's revenue based on historical data of activities for each type of product. They determine which products should be prioritized to generate the highest revenue. The results of their analysis indicate that prioritizing certain products can lead to a higher revenue.

In a study to maximize the Bintang Bakery home industry who is facing a similar challenge, including limited raw materials, machinery operating hours, and labour hours. The lack of linear programming implementation and mathematical understanding in the production process is identified as a cause for not achieving maximum profits. To address these issues, the authors propose using the simplex method for solving linear programming problems, to optimize the profit level of the Bintang Bakery home industry (Anggoro et al., 2019).

The literature review reveals that the implementation of the simplex method in the home snacks production industry holds promise for profit maximization. The simplex method offers a systematic approach to optimize resource allocation, production schedules, and workforce utilization. By incorporating numerous factors affecting profitability into a linear programming model, snack producers can make informed decisions and achieve higher profit margins.

However, it is worth noting that further research is needed to explore specific challenges and constraints unique to the home snacks production industry. Additionally, case studies and real-world implementations are necessary to validate the effectiveness of the simplex method and its impact on profitability.

CHAPTER 2: METHODOLOGY

2.1 Study Area

The study area for snack production focuses on the home industry's specialization in producing three types of snacks: Cheese Puffs, Potato Chips, and Pretzels. These snacks offer distinct flavours and textures to cater to different consumer preferences. The goal of the Snack Factory is to optimize production processes and resource allocation to achieve maximum profitability while ensuring product quality and customer satisfaction.

The production process for the snack products involves several steps, which are preparation of raw materials, mixing ingredients and making dough, distribution of snack base, baking or grilling and snack packaging.

By optimizing these production steps and resource allocation, the home industry can achieve efficient and profitable snack production while maintaining the desired quality of the snacks.

2.2 Assumptions

Various assumptions are set for this study:

1. Raw Material Quality

It is assumed that the raw materials used in snack production, such as flour, cheese, salt, spices, yeast, and etc, are of consistent quality and meet the required standards. Any variations or deviations in the quality of these raw materials are not considered in the study.

2. Production Equipment

It is assumed that the production equipment, including ovens, fryers, mixing machines, and packaging machinery, are properly maintained and function optimally throughout the production process. Any equipment breakdowns or inefficiencies are not considered in the study.

3. Production Capacity

The production capacity of the Snack Factory is assumed to be fixed and sufficient to meet the demand for snacks. The study does not take into account constraints related to expanding production capacity or limitations in meeting high-demand scenarios.

4. Production Time

The study assumes that the production steps, including preparation of raw materials, mixing ingredients, distribution of snack bases, baking/grilling, and snack packaging, are performed within reasonable time frames. The study does not consider variations in production time due to factors such as equipment downtime, maintenance, or unforeseen disruptions.

5. Packaging and Storage

It is assumed that the packaging materials used for storing snacks, such as packs, containers, or bags, adequately preserve the quality and freshness of the snacks. Factors like packaging material limitations, shelf life, and storage conditions are not considered in the study.

6. Production Cost

The study assumes that the production costs associated with raw materials, labour, energy consumption, and packaging materials remain constant. Any fluctuations or changes in production costs are not considered in the optimization model.

7. Market Demand

The study assumes that there is sufficient market demand for the Snack Factory's products. Variations in market demand, seasonal trends, and customer preferences are not considered in the study.

2.3 Resources

This study is to maximize the overall profit while adhering to a set of predefined constraints. Table 1 provides an overview of three distinct types of snacks manufactured by a snack factory, including their respective selling prices, production limits, and associated profits. Table 2 outlines the allocation table, which outlines the key constraints that need to be considered during the optimization process.

Table 1: Description of Snack Products

Products	Description	Selling Price per Pack (in RM)	Production Limit	Maximum Profit (in RM)
Cheese Puffs (x_1)	Light and crunchy puffed snacks with a delicious cheese flavour	5	800	4000
Potato Chips (x_2)	Thinly sliced and crispy potato chips, perfect for snacking	7	350	2450
Pretzels (x_3)	Crunchy and twisted pretzels, great for satisfying snack cravings	6	250	1500

Table 2: Resources Allocation Table

Materials	Cheese Puffs (x_1)	Potato Chips (x_2)	Pretzels (x_3)	Maximum Available Resources
Flour (grams)	150	200	250	350000
Cheese (grams)	50	5	7	250000
Potatoes (grams)	-	50	-	60000
Salt (grams)	5	7	8	10000
Vegetable Oil (grams)	15	25	20	100000

Baking Powder (grams)	5	-	-	50000
Sugar (grams)	12	8	15	30000
Egg (grams)	200	300	250	500000
Yeast (grams)	-	-	5	2000
Spices (grams)	5	10	5	10000
Butter (grams)	4	6	8	30000
Machine Working Hours (s)	60	90	75	108000
Labour Hours (s)	45	75	60	216000

2.4 Formulation of Linear Programming

A mathematical model is developed to optimize the production process and maximize the total profit. The linear programming model aims to achieve this objective by formulating an objective function that represents the total profit obtained from the production of various snack products.

$Max\ Z = \sum_1^3 p_i x_i$

Subject to

$$\sum_1^3 m_i x_i \leq r_i$$

$x_i \geq q_i$

Where

Z: maximum total profit

p: selling price per pack of each product

x: decision variables representing the production quantities of Cheese Puffs, Potato Chips, and Pretzels

m: resources used in the production process, including materials, machines, and labour

r: maximum availability of resources

q: current production quantities

i: index for the three snack products, with 1 representing Cheese Puffs, 2 representing Potato Chips, and 3 representing Pretzels.

2.5 Simplex Method Steps

To solve the optimization problem and find the maximum value of Z, we utilize the simplex method and the steps are discussed as below:

1. Determine the decision variables
   x_1 = Cheese Puffs
   x_2 = Potato Chips
   x_3 = Pretzels

2. Determine the objective function
   $Z = 5x_1 + 7x_2 + 6x_3$

3. Set constraints
   $Flour = 150x_1 + 200x_2 + 250x_3 \leq 350000$
   $Cheese = 50x_1 + 5x_2 + 7x_3 \leq 250000$
   $Potatoes = 50x_2 \leq 60000$
   $Salt = 5x_1 + 7x_2 + 8x_3 \leq 10000$
   $Vegetable\ Oil = 15x_1 + 25x_2 + 20x_3 \leq 100000$
   $Baking\ Powder = 5x_1 \leq 50000$
   $Sugar = 12x_1 + 8x_2 + 15x_3 \leq 30000$
   $Egg = 200x_1 + 300x_2 + 250x_3 \leq 500000$
   $Yeast = 5x_3 \leq 2000$
   $Spices = 5x_1 + 10x_2 + 5x_3 \leq 10000$
   $Butter = 4x_1 + 6x_2 + 8x_3 \leq 30000$
   $Machine\ Working\ Hours = 60x_1 + 90x_2 + 75x_3 \leq 108000$
   $Labour\ Hours = 45x_1 + 75x_2 + 60x_3 \leq 216000$
   $x_1 \geq 800$
   $x_2 \geq 350$
   $x_3 \geq 250$

4. Change the inequality (≤) to be (=) by adding slack variables.
   $150x_1 + 200x_2 + 250x_3 + s_1 = 350000$
   $50x_1 + 5x_2 + 7x_3 + s_2 = 250000$
   $50x_2 + s_3 = 60000$
   $5x_1 + 7x_2 + 8x_3 + s_4 = 10000$
   $15x_1 + 25x_2 + 20x_3 + s_5 = 100000$
   $5x_1 + s_6 = 50000$
   $12x_1 + 8x_2 + 15x_3 + s_7 = 30000$
   $200x_1 + 300x_2 + 250x_3 + s_8 = 500000$
   $5x_3 + s_9 = 2000$
   $5x_1 + 10x_2 + 5x_3 + s_{10} = 10000$
   $4x_1 + 6x_2 + 8x_3 + s_{11} = 30000$
   $60x_1 + 90x_2 + 75x_3 + s_{12} = 108000$
   $45x_1 + 75x_2 + 60x_3 + s_{13} = 216000$
   $-x_1 + s_{14} = -800$
   $-x_2 + s_{15} = -350$
   $-x_3 + s_{16} = -250$

5. Construct simplex table by inputting the coefficients of the decision variables and slack variables, which represents the initial state of the problem.
6. Perform iterations to find the maximum value of Z by conducting calculations and updating the simplex table in each iteration, resulting in a new table that brings us closer to the optimal solution.

CHAPTER 3: RESULTS AND DISCUSSION

Table 3: Optimal Snack Production

Snack Type	Variable	Actual Production	Optimal Production
Cheese Puffs	x_1	800	962
Potato Chips	x_2	350	350
Pretzels	x_3	250	250

Production Quantities:

Based on Table 3, we observed that the actual conditions have not shown optimal results. The optimal solution suggests producing 962 packs of Cheese Puffs, 350 packs of Potato Chips, and 250 packs of Pretzels. These quantities represent the ideal allocation of resources to maximize profit while considering the constraints.

Table 4: Profit of Each Product in Actual and Optimal Conditions

Snack Type	Variable	Actual Profit (in RM)	Optimal Profit (in RM)
Cheese Puffs	x_1	4000	4810
Potato Chips	x_2	2450	2450
Pretzels	x_3	1500	1500

Profit Maximization:

Based on Table 4, the actual profit (RM 7950) on the snack in actual conditions have not shown optimal results compared to optimized profit. The maximum total profit achieved from the production plan is RM 8760. This indicates that the selected production quantities yield the highest profit among all feasible solutions.

Constraint Satisfaction:

The model ensures that all constraints related to raw materials, machine hours, and labour hours are satisfied. This means that the production quantities do not exceed the availability of resources, and the production process operates within the specified limitations.

Overall, the optimal solution provides insights into the most efficient allocation of resources and production quantities that result in maximum profit while considering the given constraints. These results can guide decision-making in the production planning and resource allocation process.

CHAPTER 4: CONCLUSION

In conclusion, the linear programming model developed for optimizing the production process of snack products has provided valuable insights and solutions. By formulating an objective function to maximize the total profit and imposing various constraints, we were able to determine the optimal production quantities for Cheese Puffs, Potato Chips, and Pretzels.

Based on the results obtained from the optimization process, the optimal production quantities are as follows: 962 units of Cheese Puffs, 350 units of Potato Chips, and 250 units of Pretzels. These quantities were determined by considering the available resources, such as raw materials, machine hours, and labour hours, as well as the selling prices of the snack products.

The maximum profit achieved by the optimal solution is RM8762.50, representing the highest potential earnings from the production process. This optimal solution demonstrates the effective allocation of resources and production quantities to maximize profitability.

Based on the results obtained from the linear programming model, it is worth noting a limitation in the optimization of the production quantities for Potato Chips and Pretzels. The model suggests producing 350 units of Potato Chips and 250 units of Pretzels, which are the lower bounds set for these products. The specified constraints, such as the availability of resources and the production capacity, may restrict the optimal production quantities for Potato Chips and Pretzels. To address this limitation, further analysis and adjustments to the model may be necessary.

Overall, the application of linear programming techniques in optimizing the production process has proven to be a valuable tool for decision-making and maximizing profitability.

CHAPTER 5: REFERENCES

Almeida, F., Barbieri, J. D., Montevechi, J. a. B., Gomes, J. R. B., & Pinho, A. R. (2019). A linear programming optimization model applied to the decision-making process of a Brazilian e-commerce company. *Exacta*, *17*(3), 149–157. https://doi.org/10.5585/exactaep.v17n3.8503

Anggoro, B. S., Rosida, R., Mentari, A. M., Novitasari, C., & Yulista, I. (2019). Profit Optimization Using Simplex Methods on Home Industry Bintang Bakery in Sukarame Bandar Lampung. *Journal of Physics*, *1155*, 012010. https://doi.org/10.1088/1742-6596/1155/1/012010

Uthayageetha, D. (2017). The Maximizing the Profit in Agriculture Field by Simplex Method. International Journal of Advanced Research in Engineering and Technology (IJARET), Volume 8, Issue 6, November-December 2017, pp. 142-146, Available at SSRN https://ssrn.com/abstract=3881003

CHAPTER 6: APPENDIX

6.1 Octave Codes

```
pkg load optim
# Define the objective function coefficients
c = [-5; -7; -6];
# Define the constraint matrix
A = [150, 200, 250;
     50, 5, 7;
     0, 50, 0;
     5, 7, 8;
     15, 25, 20;
     5, 0, 0;
     12, 8, 15;
     200, 300, 250;
     0, 0, 5;
     5, 10, 5;
     4, 6, 8;
     60, 90, 75;
     45, 75, 60];
# Define the constraint
b = [350000; 250000; 60000; 10000; 100000; 50000; 30000; 500000; 2000; 10000; 30000; 108000; 216000];
# Define the lower bounds for variables
lb = [800; 350; 250];
# Define the upper bounds for variables
ub = [];

# Define the constraint type codes
ctype = repmat("U", size(A, 1), 1);

# Define the variable type codes
vartype = repmat("C", size(A, 2), 1);

# Solve the linear programming problem
[x, fval, status] = glpk(c, A, b, lb, ub, ctype, vartype);

# Display the optimal solution and profit
disp("Status: ");
disp(status);
disp("Optimal solution:");
disp(x);
disp("Maximum profit:");
disp(-fval);
```

6.2 Octave Results

```
Status:
0
Optimal solution:
   962.50
   350.00
   250.00
Maximum profit:
8762.5
```

6.3 Matlab Codes

INPUT OBJECTIVE FUNCTIONS & CONSTRAINTS

```
Variables = {'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','s_11','s_12','s_13','s_14','s_15','s_16','Sol'};
Cost = [5 7 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0];
Info = [150 200 250; 50 5 7; 0 50 0; 5 7 8;
        15 25 20; 5 0 0; 12 8 15; 200 300 250;
        0 0 5; 5 10 5; 4 6 8; 60 90 75;
        45 75 60; -1 0 0; 0 -1 0; 0 0 -1];
b = [350000; 250000; 60000; 10000; 100000; 50000; 30000; 500000; 2000; 10000; 30000; 108000; 216000; -800; -350; -250];
s = eye(size(Info, 1)); %identity matrix
A = [Info s b] %combine into single matrix
```

STARTING BFS

```
BV= [] ;
for j=1:size (s,2)
    for i=1:size(A, 2)
        if A(:,i)==s (:,j)
            BV = [BV i];
        end
    end
end
```

CALCULATE VALUE OF ROW Zj-Cj

```
B = A(:, BV);
A = inv(B)*A;
ZjCj = Cost(BV)*A-Cost;

%%%% Print Table
ZCj = [ZjCj; A];
SimplexTable = array2table(ZCj);
SimplexTable.Properties.VariableNames(1:size(ZCj,2)) = Variables
```

START SIMPLEX METHOD

```
RUN = true;
while RUN

ZC = ZjCj(:,1:end-1);

if any (ZC<0)
    fprintf ('The Current BFS is NOT Optimal \n');

    %%%% FINDING THE ENTERING VARIABLE
    [Entval, pvt_col] = min (ZC);
    fprintf('Entering Column = %d \n', pvt_col);

    %%%% FINDING THE LEAVING VARIABLE
    sol = A (:, end);
    Column = A (:, pvt_col);

    r = find(Column >0); %% to find minimum ratio
    ratio = inf.*ones(1,length(sol));
    ratio(r) = sol(r)./Column(r);

    [minR, pvt_row] = min(ratio);
    fprintf('Leaving Row = %d \n', pvt_row);

    %%%% UPDATE BV
    BV(pvt_row) =pvt_col;

    %%%% UPDATE TABLE FOR NEXT ITERATION
    B = A (:, BV);
    A = inv(B)*A;
    ZjCj= Cost(BV)*A-Cost;

    %%%% PRINT TABLE
    ZCj = [ZjCj;A];
    TABLE = array2table(ZCj);
    TABLE.Properties.VariableNames(1:size(ZCj,2)) = Variables

else
    RUN = false;
    fprintf ('CURRENT BFS IS OPTIMAL \n');

end

end
```

6.4 Matlab Results

TABLE =

17×20 table

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	s_11	s_12	s_13	s_14	s_15	s_16	Sol
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.083333	0	0	0.5	0.25	8762.5
0	0	0	1	0	0	0	0	0	0	0	0	0	0	-2.5	0	0	-25	62.5	73125
0	0	0	0	1	0	0	0	0	0	0	0	0	0	-0.83333	0	0	-70	-55.5	1.9838e+05
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	50	4.4409e-15	42500
0	0	0	0	0	0	1	0	0	0	0	5.5511e-17	0	0	-0.083333	0	0	-0.5	1.75	737.5
0	0	0	0	0	0	0	1	0	0	0	0	0	0	-0.25	0	0	2.5	1.25	71812
0	0	0	0	0	0	0	0	1	0	0	0	0	0	-0.083333	0	0	-7.5	-6.25	45188
0	0	0	0	0	0	0	0	0	1	0	0	0	0	-0.2	0	0	-10	0	11900
0	0	0	0	0	0	0	0	0	0	1	0	0	0	-3.3333	0	0	8.8818e-15	1.3323e-14	1.4e+05
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	250
0	1	0	0	0	0	0	0	0	0	0	0	0	0	4.6259e-18	0	0	-1	0	350
0	0	0	0	0	0	0	0	0	0	0	0	0	1	-0.066667	0	0	0	3	22050
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.016667	0	0	1.5	1.25	962.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.75	1	0	7.5	3.75	1.3144e+05
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.016667	0	1	1.5	1.25	162.5
0	0	0	0	0	0	0	0	0	0	0	0	1	0	-0.083333	0	0	2.5	-1.25	437.5
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	750

CURRENT BFS IS OPTIMAL

OptimalBFS =

1×20 table

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	s_11	s_12	s_13	s_14	s_15	s_16	Sol
962.5	350	250	73125	1.9838e+05	42500	737.5	71812	45188	11900	1.4e+05	750	437.5	22050	0	1.3144e+05	162.5	0	0	8762.5

6.5 Python Codes

```python
# @title Optimization Finding
from pulp import *
import pandas as pd
from tabulate import tabulate

# Create a maximization problem
prob = LpProblem("Snacks_Profit_Maximization", LpMaximize)

# Define the decision variables
x1 = LpVariable("x1", lowBound=800, cat='Continuous')
x2 = LpVariable("x2", lowBound=350, cat='Continuous')
x3 = LpVariable("x3", lowBound=250, cat='Continuous')

# Define the objective function
prob += 5 * x1 + 7 * x2 + 6 * x3

# Define the constraints
prob += 150 * x1 + 200 * x2 + 250 * x3 <= 350000
prob += 50 * x1 + 5 * x2 + 7 * x3 <= 250000
prob += 50 * x2 <= 60000
prob += 5 * x1 + 7 * x2 + 8 * x3 <= 10000
prob += 15 * x1 + 25 * x2 + 20 * x3 <= 100000
prob += 5 * x1 <= 50000
prob += 12 * x1 + 8 * x2 + 15 * x3 <= 30000
prob += 200 * x1 + 300 * x2 + 250 * x3 <= 500000
prob += 5 * x3 <= 2000
prob += 5 * x1 + 10 * x2 + 5 * x3 <= 10000
prob += 4 * x1 + 6 * x2 + 8 * x3 <= 30000
prob += 60 * x1 + 90 * x2 + 75 * x3 <= 108000
prob += 45 * x1 + 75 * x2 + 60 * x3 <= 216000

# Solve the problem
prob.solve()

# Create a table to store the results
results_table = pd.DataFrame(columns=['Snack', 'Selling Price (RM)', 'Initial Value', 'Optimized Value', 'Initial Profit (RM)', 'Optimized Profit (RM)'])

# Define the initial values and selling prices
initial_values = {'x1': 800, 'x2': 350, 'x3': 250}
selling_prices = {'x1': 5, 'x2': 7, 'x3': 6}
initial_profits = {snack: initial_values[snack] * selling_prices[snack] for snack in initial_values}

# Add the snack values and profit to the table
initial_value_total = sum(initial_values.values())
optimized_value_total = sum([v.varValue for v in prob.variables()])
for v in prob.variables():
    snack_name = v.name
    initial_value = initial_values[snack_name]
    optimized_value = v.varValue
    selling_price = selling_prices[snack_name]
    initial_profit = initial_profits[snack_name]
    optimized_profit = optimized_value * selling_price
    results_table = results_table.append({'Snack': snack_name, 'Selling Price (RM)': selling_price, 'Initial Value': initial_value, 'Optimized Value': optimized_value,
                                          'Initial Profit (RM)': initial_profit, 'Optimized Profit (RM)': optimized_profit}, ignore_index=True)

# Add the total profit to the table
total_initial_profit = sum(initial_profits.values())
total_optimized_profit = value(prob.objective)
results_table = results_table.append({'Snack': 'Total', 'Selling Price (RM)': '', 'Initial Value': initial_value_total, 'Optimized Value': optimized_value_total,
                                      'Initial Profit (RM)': total_initial_profit, 'Optimized Profit (RM)': total_optimized_profit}, ignore_index=True)

# Round up the values in the table
results_table = results_table.round(decimals=2)

# Set the table format
table_format = 'fancy_grid'

# Print the status of the solution
print("Status:", LpStatus[prob.status])

# Print the results table
print("\nResults:")
print(tabulate(results_table, headers='keys', tablefmt=table_format))

# Print the optimal profit separately
print("\nTotal Initial Profit (RM) =", total_initial_profit)
print("Total Optimized Profit (RM) =", total_optimized_profit)
```

6.6 Python Results

```
Status: Optimal

Results:
```

	Snack	Selling Price (RM)	Initial Value	Optimized Value	Initial Profit (RM)	Optimized Profit (RM)
0	x1	5	800	962.5	4000	4812.5
1	x2	7	350	350	2450	2450
2	x3	6	250	250	1500	1500
3	Total		1400	1562.5	7950	8762.5

```
Total Initial Profit (RM) = 7950
Total Optimized Profit (RM) = 8762.5
```