Optimization of the Quantity of Crackers Production at CV. XYZ Using the Linear Programing Method

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ABSTRACT

The purpose of the research conducted is to optimize production activities at CV. XYZ. The method used in this study is linear programming and uses the MATLAB application. CV. XYZ itself produces three types of crackers, namely small rose crackers, large rose crackers and gendar crackers. Each cracker is made with its own measurements and ingredients. The first step taken in seeking maximum profit is to determine the decision variables where the variables are (X1) for small rose crackers, (X2) for large rose crackers, and (X3) for gendar crackers. Then determine the main function by looking at the profits that can be obtained by the company where the profits obtained are IDR. 1500 for small rose crackers, IDR 500 for large rose crackers and IDR. 500 for gendar crackers so that the objective function can be written as Z = 1500X1 + 500X2 + 500X3. The next step is to determine the constraint function of the raw materials used by the company to make crackers, the raw materials include starch, tapioca flour, salt, and oil. The results of the study related to the optimization carried out in production activities are that the maximum profit that can be obtained by the company is IDR. 8.823.529 with the production that can be done is 58,824 small rose crackers, and 0 large rose crackers and 0 gendar crackers.

Keywords: Linear Programing, Optimization, Maximum Profit, Production, Objective Function

INTRODUCTION

The snack industry sector such as crackers is one of the promising sectors and has great potential in the economy in Indonesia. This is because crackers are one of the snacks that are very popular with many people in Indonesia, from children to adults because of their savory and delicious taste and affordable price. Crackers made from tapioca flour and various other ingredients are widely used as snacks or side dishes such as noodles or meatballs

The snack food industry sector such as crackers is increasing day by day, this makes competition between companies increasingly tight and requires companies to continue to innovate and always maintain the quality of their products so as not to lose in competition. In addition, optimizing the amount of production to meet market demand is one thing that is no less important because production optimization is the main key in facing increasingly competitive competition.

The snack industry sector such as crackers has experienced significant growth in recent years. Based on data from the Ministry of Agriculture, per capita cracker consumption in Indonesia reached 0.197 ounces per week in 2023, showing an increase compared to the previous year of 6.56%. In addition, crackers are also one of the snacks that contribute to Indonesia's export market with an export value reaching US$37.36 million in 2022

However, despite its great potential, small and medium industries (SMEs) in this sector face various challenges.

One of them is the management of limited raw materials and the need to remain efficient in the production process. Optimizing production is a strategic step in ensuring business sustainability amidst increasingly competitive competition. This study aims to evaluate the production process at CV XYZ using the linear programming method to identify optimal strategies that can increase profits and production efficiency.

CV XYZ is a company engaged in the food industry that produces crackers with various types of crackers including small rose crackers, large rose crackers and gendar crackers in carrying out its production activities one of the challenges experienced by this company is optimizing the amount of production. optimizing the amount of cracker production produced by CV XYZ will have a great impact on increasing operational efficiency, reducing production costs, increasing productivity, reducing material waste, and also having an impact on customer satisfaction by this study was conducted to evaluate and provide solutions related to optimizing the amount of cracker production at CV.XYZ by considering aspects of production and other factors that can affect production.

LITERATURE REVIEW

Optimization is a process or action to find the best solution to a problem that occurs. According to S. Taha (2017) optimization is the search for the best or optimal value for a function in limited conditions or with certain constraints.

FS Hilier (2014) said that optimization is the process of selecting the best alternative from a series of available alternatives using certain criteria and considering the existing constraints or limitations. Winston WL (2004) said that optimization is finding the best possible value of an objective function, which can be minimum cost or maximum profit, by considering various restrictions or conditions in the system. From the explanations above, it can be concluded that optimization is a method used to find the best alternative solution to a problem that occurs by considering various constraints and limitations of the problem . From this definition, optimization is closely related to production activities in a company. Production activities in a company will always face problems that occur, from the problems that occur we are required to find the best solution by considering various constraints that occur. Optimization is closely related to the linear programming method

Linear programming is a method used to find the best solution in solving optimization problems by modeling the problem into mathematical form and solving it with linear equations or inequalities. Linear programming is done with the aim of solving the problem of allocating limited resources by finding the best solution that can be done to achieve optimum results and good production efficiency.

According to Heizer and Reinder (2017) good production management can increase efficiency and reduce waste which can ultimately reduce operational costs in addition to increasing production efficiency. Production efficiency is a condition where the utilization of existing resources is carried out optimally so that the output produced is also maximized

Several previous studies discussed production optimization using linear programming optimization methods , including those conducted by Selvia Apriliyanti in 2019 where this research was conducted at PT. Indopal Harapan Murni with the aim of determining the optimal production profit that can be generated by the company, the results of this study are that the profit obtained by PT Indopal Harapan Murni is optimal, which is IDR 872,210,000. Then the next study was conducted by Ilham Nuryana where this research was conducted at Riana Kersen UMKM with a profit of IDR 32,000 including the production output of 11 pieces of fried chicken products in one day.

RESEARCH METHOD

This research was conducted through a linear programming approach with the help of MATLAB software. The selection of MATLAB is based on its ability to handle complex optimization problems efficiently. The stages of the research include :

a. **Problem identification**

find out the problems that often occur in CV XYZ related to the production process, especially regarding raw materials

b. **Data Collection**

Data is taken from CV. XYZ data taken in the form of raw material data, production capacity, and profit per unit of crackers.

c. **Mathematical Model Formulation:**

- Objective Function: Maximize company profits.
- Constraints: Capacity of raw materials (starch, tapioca flour, salt, oil).

d. **Model Implementation**

The mathematical model is formulated in MATLAB using the linprog function .

e. **Analysis Results**

Evaluation is conducted to understand the impact of changes in raw material capacity on maximum profit.

f. **Analysis External and Internal Factor**

Conduct analysis related to external and internal factors that can influence the company's operational activities

RESULT AND DISCUSSION

a. Problem Identification

The main problem that occurs at CV.XYZ is the limited availability of raw materials which reduces the number of products produced, this disrupts production when demand increases.

b. Data collection

The initial stage is to collect data from CV.XYZ. Data in the form of raw material capacity and raw materials used to make the three types of crackers and then data related to the profits of each type of cracker. The following is data from CV.XYZ

Table 1. Raw material Capacity

Raw Material	Total Stock (Kg)
Starch Flour	100
Tapioca	150
Salt	20
Oil	100

Table 2. Raw material used to make crackers

Types of Crackers	**Raw Materials (Kg)**			
	Starch	**Tapioca flour**	**Salt**	**Oil**
Small Rose Crackers	5	20	2	17
Big Rose Crackers	5	15	1	10

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Gendar Crackers	15	3	1	10
Material Capacity	100	150	20	100

Table 3. Production Profits

Types of Crackers	Profit (Per Pack)
Small Rose Crackers	1500
Big Rose Crackers	500
Gendar Crackers	500

From the table data above consisting of available raw materials, raw material requirements per type of cracker and profit per unit of production. The data will later be entered into MATLAB in the form of a matrix and vector. The following is a formulation in MATLAB where the data has been changed into matrix and vector form

Figure 1 Data Has Been Changed In to Matrix

JURNALRISETOPERASI.m × | JURNALRISETOPERASI2.m × | untitled2 × | +

/MATLAB Drive/JURNALRISETOPERASI.m

```
% Koefisien fungsi tujuan (negatif karena linprog meminimalkan)
f = [-1500, -500, -500];  % Maksimalkan keuntungan

% Koefisien matriks A (batasan bahan baku)
A = [
    5, 5, 15;  % Tepung Kanji
    20, 15, 3;  % Tepung Tapioka
    2, 1, 1;  % Garam
    17, 10, 10;  % Minyak
];

% Vektor batasan (bahan baku yang tersedia)
b = [100, 150, 20, 100];  % Kapasitas bahan baku

% Batasan non-negatif untuk jumlah produk
lb = [0, 0, 0];  % Tidak ada produksi negatif
```

c. Mathematical Model Formulation

The next stage is to determine the objective function and decision variables, the objective function is formulated to maximize profits. The decision variables are taken from the products produced. The decision variables are: X1 for rose crackers, X2 for large rose crackers and X3 for gendar crackers the objective function can be seen from the profit table obtained the objective function of this case is :

Z = 1500X1 + 500X2 + 500X3

In MATLAB, the objective function is written as a vector of the profit coefficients of each decision variable. The following is the formulation of the objective function written in the MATLAB program.

Figure 2 Objective Function

JURNALRISETOPERASI.m × | JURNALRISETOPERASI2.m × | untitled2 × | +

/MATLAB Drive/JURNALRISETOPERASI.m

```
% Koefisien fungsi tujuan (negatif karena linprog meminimalkan)
f = [-1500, -500, -500];  % Maksimalkan keuntungan

```

The next step is to determine the constraint function of each raw material inventory. The following are the constraint functions for starch raw materials:

5X1 + 5X2 + 15X3 ≤100

Constraint function for tapioca flour:

20X1 + 15X2 + 3X3 ≤ 150

Constraint Function for salt:

2X1 + X2 + X3 ≤20

Constraint function for oil:

17X1 + 10X2 +10X3 ≤ 100

For:

X1 ≥0, X2 ≥0, X3 ≥0

The following is the implementation of the raw material constraint function for the three types of crackers in MATLAB

Figure 3 Constraint Function of the Raw Material

```
% Koefisien matriks A (batasan bahan baku)
A = [
    5, 5, 15;  % Tepung Kanji
    20, 15, 3;  % Tepung Tapioka
    2, 1, 1;  % Garam
    17, 10, 10;  % Minyak
];

% Vektor batasan (bahan baku yang tersedia)
b = [100, 150, 20, 100];  % Kapasitas bahan baku

% Batasan non-negatif untuk jumlah produk
lb = [0, 0, 0];  % Tidak ada produksi negatif
```

d. Model Implementation.

After determining the decision variables, objective function, and constraint function, the next step is to use the application for this problem. This program uses the MATLAB application. MATLAB provides a built-in function to solve linear programming problems, namely linprog . The following is a formulation written in the MATLAB application to find the optimum value.

Figure 4 Using The linprog function .

```
% Mencari solusi optimasi menggunakan linprog
options = optimoptions('linprog', 'Display', 'off');  % Menonaktifkan output eksekusi
[x, fval] = linprog(f, A, b, [], [], lb, [], options);

% Menghitung keuntungan maksimum
keuntungan_maksimum = -fval;  % Karena kita mengalikan fungsi tujuan dengan -1

% Menampilkan hasil
disp('Jumlah produk yang harus diproduksi:');
disp(['Kerupuk Mawar Ukuran Kecil: ', num2str(x(1))]);
disp(['Kerupuk Mawar Ukuran Besar: ', num2str(x(2))]);
disp(['Kerupuk Gendar: ', num2str(x(3))]);
disp(['Keuntungan Maksimum: ', num2str(keuntungan_maksimum)]);
```

After all the formulations are written as shown in the image below, then just press the Run Section button. After the Run Section button is pressed, the Command Window will show the calculation results. Here is the overall formulation.

Figure 5 Overall Formulation

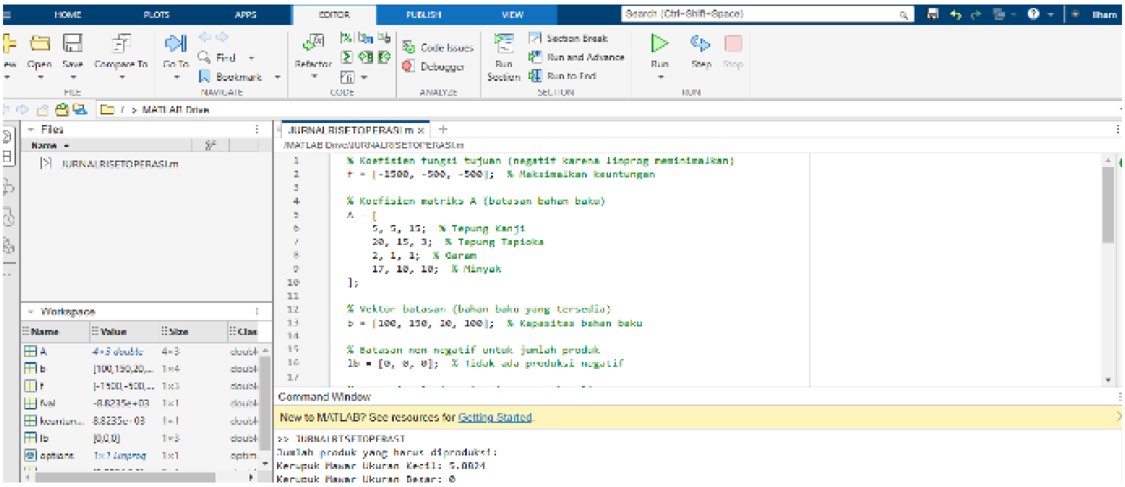
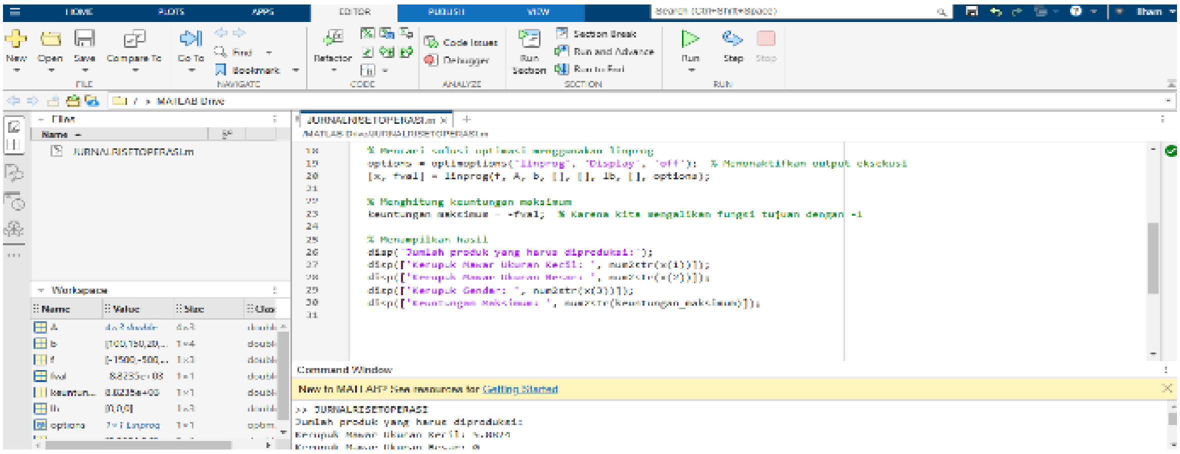
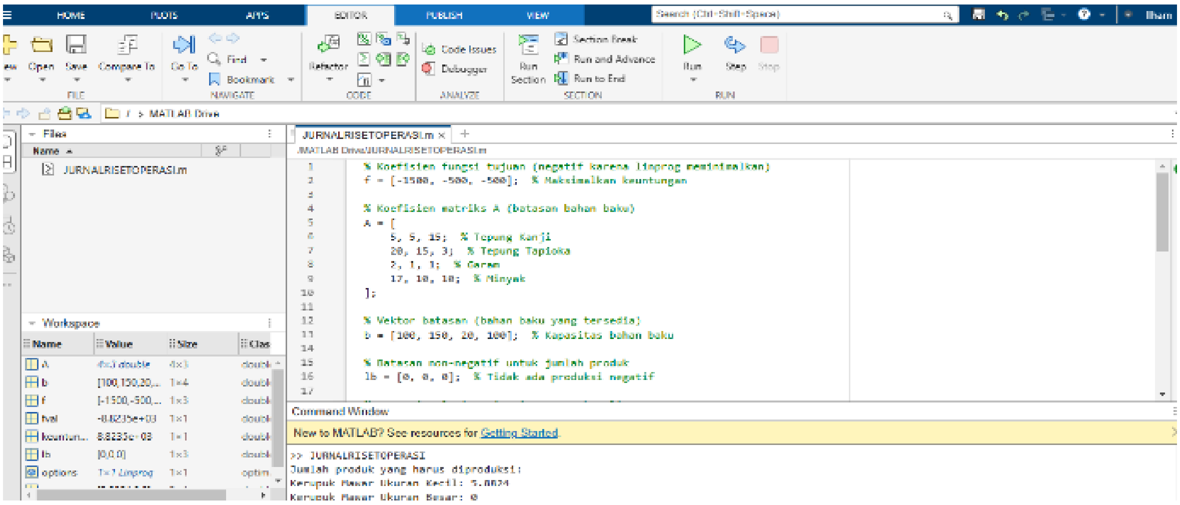


Figure 6 Formulation of Mathematical Model In MATLAB



From the formulation added to the MATLAB application, the following results were obtained:

Figure 7 Result



After the mathematical model is entered into the MATLAB column, the output obtained from the MATLAB program for solving the mathematical model above is as below.

Figure 8 Output of the Program

e. **Analysis Result.**

From the results of the formulation in the MATLAB application, it is known that the maximum profit that can be obtained is IDR 8.823.529 with details of the production of small rose crackers of 58,824 pcs, large rose crackers of 0 pcs, and gendar crackers of 0 pcs. and continued for large rose crackers and gendar crackers.

Sensitivty Analysis

Sensitivity Analysis to examine how changes in key parameters affect the optimal solution, here are the points of analysis:

1. Profit Per Unit Impact of Change: If the profit per unit of large or aggressive rose crackers increases to close to or exceed the profit of small rose crackers (IDR 1,500), the production allocation may change to include one or both types of products. Simulation Scenario: Increase the profit per unit of large and aggressive rose crackers, then re-evaluate the model.
2. Raw Material Availability Impact Change: If the capacity of raw materials such as starch flour and tapioca flour increases, companies may be able to produce more varied product combinations. Simulation Scenario: Add the raw material capacity in a certain proportion (e.g., a 10-20% increase), then see if the production of large and fragile rose crackers becomes optimal.
3. Production Capacity Impact Change: Changes to physical production capacity (e.g. maximum number of products per day) can affect total output and maximum profit. Simulation Scenarios: Limit production capacity (e.g. to 50,000 pcs) to understand the influence on the optimal solution.

The following are the results of the sensitivity analysis scenario simulation :

Scenario 1: Increase profit per unit When profit per unit of large and gendar rose crackers increases from Rp 500 to Rp 1,000

Optimal production:

- Small rose crackers: 0 pcs
- Large rose crackers: 5 pcs
- Gendar crackers: 5 pcs

Maximum profit: IDR 10,000

Scenario 2: Increasing the capacity of raw materials When the capacity of raw materials (starch flour becomes 120 kg, tapioca flour becomes 180 kg)

Optimal production:

- Small rose crackers: 58,824 pcs

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- Large rose crackers: 0 pcs
- Gendar crackers: 0 pcs

Maximum profit: IDR 8,823,529

Scenario 3: Limiting total production capacity When the total production capacity is limited to 50,000 pcs

Optimal production:

- Small rose crackers: 58,824 pcs
- Large rose crackers: 0 pcs
- Gendar crackers: 0 pcs

Maximum profit: IDR 8,823,529

Analysis of External and Internal Factor

1. **Market Demand**

   - Demand Trends: The market demand for certain types of crackers (small, large, gendar) can change over time. For example, small rose crackers may be more popular because they are more affordable.
   - Season: Demand can increase during certain holidays or seasons, so companies must be able to meet this surge.
   - Market Segmentation: Companies must be able to serve market segments that are sensitive to price, quality, and product innovation

2. **Competition with Competitor**

   - Competitor Analysis: Identify key competitors, the selling price of their products, and their competitive advantages (such as quality or branding).
   - Price and Margin: If a competitor sells at a lower price, the company needs to adjust its pricing strategy or increase the value of the product.
   - Product Uniqueness: Are CV crackers. XYZ has a distinctive feature that sets it apart from the competition?

3. **Production Capacity**

   - Capacity is currently limited by raw materials and infrastructure, which limits the number of products that can be produced.
   - The use of production capacity is only optimal for one type of cracker (small rose), so it is difficult to diversify production

CONCLUSION

The results of the study conducted through the MATLAB application show that the profit that can be obtained by the company is IDR 8,823,529 with the production that can be done is 58,824 small rose crackers, and 0 large rose crackers and 0 gendar crackers. The results obtained from the MATLAB program show that the available raw materials are not sufficient to produce large rose crackers and gendar crackers, so all resources are allocated to produce small rose crackers. This decision is based on a higher profit per unit (IDR. 1.500 per

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pack). And this is also in line with the results of the sensitivity analysis where the maximum profit obtained is IDR8,823,529 by increasing the capacity of the standard and limiting the total production, the optimal production is 58,824 pcs of small rose crackers, 0 pcs of large rose crackers and 0 pcs of gendar crackers.

From this, several things can be concluded, including:

1. *Maximum Profit:* The company can achieve a maximum profit of IDR 8,823,529 by producing only 58,824 pcs of small rose crackers.

2. *Production Focus on Small Rose Crackers:* All raw materials are allocated to produce small rose crackers because they provide the highest profit margin (IDR 1,500/unit), compared to large rose crackers and gendar crackers (IDR 500/unit).

3. *Raw Material Constraints:* The available raw material capacity is the main barrier to producing large rose crackers and gendar crackers. Specifically :

- *Starch Flour:* The total raw material requirements for large and gendar rose crackers are greater than for small rose crackers.

- *Tapioca Flour and Oil:* This ingredient is also used intensively, limiting product diversification

And here are the reasons why only small rose crackers are produced:

1. *Higher Profit Per Unit:* With a margin of Rp 1,500/unit, small rose crackers provide almost triple profits compared to the other two products. Therefore, mathematically, producing small rose crackers is the optimal decision to maximize profits.

2. *Raw Material Limitations:* The current raw material capacity is not enough to support the production of large or gendar rose crackers in significant quantities. If part of the raw materials are allocated to other products, then the total profit will be reduced.

3. *Resource Allocation Efficiency:* MATLAB models show that allocating entire resources to small rose crackers results in the most efficient utilization of raw materials, with no waste or idle capacity

4. *Sensitivity Analysis:* Even when profit margins or market demand for large and volatile rose crackers increase, raw material constraints still hinder production diversification. Additional raw materials (e.g., starch or tapioca) are needed to enable the production of other types of crackers

Suggestion

The following are suggestions that can be applied by CV.XYZ both from internal factors (resource allocation, production scheduling, pricing strategy) and external factors (market demand, competition)

Internal Factors:

1. **Resource Allocation:**

- Focus on High Margin Products : Since small rose crackers provide the highest margins, allocate most of the raw materials to produce these products.

- Efficient Use of Raw Materials: Carry out a comprehensive evaluation of the production process to reduce waste of raw materials, especially starch and tapioca flour, which are the main obstacles.

- Diversification: If you want to increase the production of large rose crackers or gendar, adjust the composition of raw materials for better efficiency, without sacrificing quality. To support product diversification and increase total production, CV.XYZ can increase raw material capacity because this is the main obstacle

Practical Implications:

- Optimizing raw material allocation can increase output at fixed costs, resulting in greater profit margins.

2. **Production scheduling**

- Demand Based Production: Production of large rose crackers and gendar can be carried out only when there is additional demand or to fulfill special orders.
- Flexible Scheduling: Implement a flexible production system to adjust production quantities based on seasonal demand frequencies, such as during holidays.
- Production Rotation: Schedule production rotation between products to maximize raw material utilization and production capacity.

Practical Implications:

- Dynamic scheduling allows companies to respond quickly to market changes without the risk of overstock or product shortages.

3. **Pricing Strategies.**

- Premium Prices for Featured Products: Increase the price of small rose crackers by branding them to "premium" or "traditional", highlighting the quality of the raw materials.
- Promotion on Products with Low Demand: Carry out discounts or bundling for large rose crackers and gendar to increase market attractiveness.
- Price Segmentation Based on Location : Set different prices for local markets and markets with higher purchasing power.

Practical Implications:

- The right pricing strategy can increase revenue from market segments that are sensitive to quality or price.

External Factors

1. **Market Demand:**

- Product Diversification: Apart from focusing on small rose crackers, we are willing to develop new variants or premium products to prevent consumer boredom.
- Market Research: Conduct surveys or analyze sales data to find out consumer preferences.
- Flexible Capacity Increase : Ensure production capacity can be increased temporarily to meet seasonal demand

Practical Implication:

- Helping companies remain responsive to market dynamics, whether facing surges in demand or fluctuations in demand

2. **Competition with competitors**

- Pricing Strategy: providing discounts or bundling packages to attract customers without sacrificing

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profit margins.

- Brand Enhancement : Use branding and marketing to create added value, for example "healthy crackers" with natural ingredients.

- Partnership Strategy: Working with distributors or resellers to expand the market.

Practical Implication:

- Increase customer attraction and expand market access without the need for large investments

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