تحسين كفاءة الإنتاج باستخدام برمجة De Nova : دراسة حالة في مصنع الألبان الذهبي

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ECONOMICS AND ADMINISTRATIVE STUDIES JOURNAL (EASJ)
EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

تحسين كفاءة الإنتاج باستخدام برمجة De Nova : دراسة حالة في مصنع الألبان الذهبي

Improving Manufacturing Efficiency Using De Novo Programming: Case study at the Al-Dhahabi Dairy Plant

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تاريخ الاستلام: 2025/02/10 تاريخ القبول: 2025/03/23 تاريخ النشر: 2025/12/01
Received: 10/02/2025 Accepted: 23/03/2025 Published: 01/12/2025

المستخلص:

تبحث هذه الدراسة في تعزيز كفاءة الإنتاج في مصنع الذهبي للألبان من خلال تطبيق نموذج برمجة رياضية من الأساس. أثبتت أساليب التحسين التقليدية مثل البرمجة الخطية وبرمجة الأهداف عدم كفايتها لعمليات مصنع الألبان حيث تتعامل مع توفر المواد الخام كقيود ثابتة، وتفشل في مراعاة الطبيعة المتغيرة لاقتصاديات إنتاج الألبان. تتناول الدراسة عدة تحديات حرجة: تقلبات تكاليف المواد الخام التي تختلف مع كميات الشراء (مع بعض الموردين الذين يقدمون خصومات للكميات الكبيرة بينما يفرض آخرون أسعارًا أعلى بعد تجاوز حدود معينة)؛ قيود صارمة على سعة الإنتاج؛ متطلبات الحد الأدنى من الإنتاج للحفاظ على الحضور في السوق؛ والحاجة إلى توزيع أمثل للميزانية لتعظيم العوائد. من خلال تطوير نموذج رياضي شامل يُحسّن بشكل ديناميكي تخصيص الموارد مع مراعاة هذه التحديات، حققت الدراسة تحسينات كبيرة في كفاءة العمليات. أدى التطبيق العملي للنموذج إلى تحديد كميات الإنتاج المثلى لكل منتج رئيسي من منتجات الألبان (الحليب، القشدة، الجبن، ومصل اللبن) بناءً على الطلب في السوق والميزانية المتاحة، مما أدى إلى زيادة الربحية بمقدار 7,561,686.5 دينار عراقي. يعود نجاح النموذج إلى قدرته على تخصيص الموارد بدقة، وتحسين كفاءة شراء المواد الخام، والتكيف مع تقلبات الأسعار، وتقليل الهدر مع الحفاظ على جودة المنتج. بناءً على هذه النتائج، توصي الدراسة باعتماد نموذج دي نوفو كأداة أساسية لتخطيط الإنتاج وإدارة الموارد في عمليات تصنيع الألبان ومن التحديات الآخر هوا الميزانية يمكن ان تستخدم بكفاءة لتجنب الخسارة.

الكلمات المفتاحية: برمجة de novo، خطة الإنتاج، معمل الالبان الذهبي ، وأسعار متغيرة ، تخصيص الميزانية

بحث مستل من رسالة ماجستير

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EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Abstract:

This study investigates the enhancement of production efficiency at Al-Dhahabi Dairy Factory through the implementation of an ab initio mathematical programming model. Traditional optimization approaches like linear and goal programming have proven inadequate for the dairy's operations as they treat raw material availability as fixed constraints, failing to account for the dynamic nature of dairy production economics. The research addresses several critical challenges: fluctuating raw material costs that vary with purchase quantities (with some suppliers offering bulk discounts while others impose premium pricing beyond certain thresholds); strict production capacity constraints; minimum production requirements to maintain market presence; and the need for optimal budget allocation to maximize returns. By developing a comprehensive mathematical model that dynamically optimizes resource allocation while accounting for these challenges, the study achieved significant improvements in operational efficiency. The practical application of the model determined optimal production quantities for each major dairy product (milk, cream, cheese, and whey) based on market demand and available budget, resulting in an increased profitability of IQD 7,561,686.5. The model's success stems from its ability to allocate resources accurately, improve efficiency in raw material procurement, adapt to price fluctuations, and reduce waste while maintaining product quality. Based on these results, the study recommends adoption of the de novo model as a fundamental tool for production planning and resource management in dairy manufacturing operations. Another challenge is the budget that can be used efficiently to avoid loss.

Keywords: De novo programming, variable prices , golden dairy factory, production plan, budget allocation

Introduction

Every organization strives to find the best way to make appropriate decisions. Traditionally, organizations rely on methods such as intuition or trial and error, which are often costly, inefficient, and produce inaccurate results. Therefore, there is a need to develop a method to ensure accurate and cost-effective decisions. This method is linear programming, which has become one of the most used methods for solving various economic problems. Linear programming aims to determine the mechanism for allocating limited resources to alternative uses to achieve organizational goals.

The intertwining of scientific, economic, environmental, and competitive aspects in the modern economy, coupled with the exponential growth of business activities and the increasing complexity of industrial organizations, has led to the emergence of new, complex, and significant challenges. These challenges require the improvement of production lines, which is one of the most critical and complex decisions faced by decision makers, especially in operations. Therefore, organizations resort to scientific methods to analyze problems and find practical solutions. These methods

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

include operations research, which uses various quantitative techniques to model real-world scenarios into mathematical and logical frameworks.

Improving a production line aims to achieve specific goals with limited resources by exploring various alternatives and selecting the best one based on the decision maker's perception of the decision environment. Therefore, production line optimization includes all the necessary activities and considerations to find the best solution to a problem. This process focuses on defining production factors, collecting, and presenting data, converting data into information and knowledge, and formulating the problem mathematically in a model. The model is then solved using operations research techniques, including de novo programming methods.

Industrial companies, including Al Dhahabi Dairy, face significant challenges in improving production line efficiency while making effective use of available resources. These challenges include rising raw material costs, managing limited resources, and achieving optimal production at a lower cost to ensure operational continuity and profitability. With fluctuating raw material prices, variable costs, and volume discounts, there is a growing need for practical and precise solutions to improve production processes. The core issue is making the best production decisions to ensure the highest efficiency at the lowest possible cost. To meet these challenges, organizations rely on a range of scientific methods and tools to help decision makers choose the best solution from multiple alternatives. Decision makers use quantitative tools and techniques such as de novo programming, which is one of the main operations research methods for solving economic and management problems.

The Researchers Sasaki et al. (2016) addressed the use of ab initio programming with fuzzy objectives and constraints in the optimal system design problem. The research focused on integrating fuzzy elements into ab initio programming to improve the accuracy of decision-making under uncertain conditions commonly found in real production environments. The study showed that combining genetic algorithms with ab initio programming can improve the ability to manage unexpected changes in resources and production, allowing the design of more flexible and adaptable production systems. Daoudi Yamina and Moulay Omar Latifa (2017) used ab institution planning methods in preparing production budgets. Through the study, the researchers showed how to use ab initio planning to prepare a production budget and concluded that production budgeting is an important tool for estimating production needs and that there is a general lack of awareness among Algerian economic organizations about the importance of quantitative methods, especially in this area of ab initio planning. Othman Omar (institution proposed a min-max goal programming approach to solve the ab initio planning problem based on multi-objectives. In their study, positive and negative ideal solutions were used in the goal programming using the min-max method. The goal of this reformulation was to achieve a satisfactory balance between the best and worst solutions to the problem. Beyond that, Researchers Li, and Yong (2018) used linear programming to optimize production lines in the electronics industry. The researchers focused on how linear programming can be used to improve resource allocation and reduce operating costs under changing market constraints. The study showed that linear programming significantly helped improve production efficiency and reduce waste. The linear programming model was used to plan production based on expected demand while minimizing the difference between production and cost. The study proved that linear programming can be a powerful tool for effective production planning in modern industries.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

1. Research objectives

This research aims to improve the production line efficiency at Al-Dhahabi Dairy Factory by implementing the De Novo programming approach, which enables comprehensive redesigning of the production system to achieve minimum cost and maximum profit. The main objectives of the research are to study the impact of raw material price fluctuations on the production line and profitability, and to develop effective strategies for dealing with rising raw material costs and taking advantage of available discounts when purchasing in bulk quantities. The research also seeks to employ the De Novo mathematical model, which treats the budget as a pivotal element in the optimization process, handling it as a dynamic variable rather than a fixed constraint. This allows for optimal allocation of financial resources in a way that reduces total costs and increases profitability, while considering the various production and marketing constraints facing the factory.

2. Concept of Production Planning

The use of linear programming in production planning within an organization has been defined in several ways. The most important definitions of production planning include the following:[1]

Master production planning is defined as the determination of production quantities and times over the medium term (usually in the range of 3 to 18 months). In this process, operations managers attempt to find the best way to meet projected demand by adjusting production rates, staffing levels, inventory levels, overtime pay, subcontractor rates, and other controllable variables. Russell Taylor defines it as the determination of the organizational resources required to meet medium-term (6 to 12 months) demand.

Krajewski and Ritzman define it as a statement of the organization's production rates, workforce levels, and inventory levels based on customer demand and capacity constraints. This statement is framed within a specific time in the future.

On this basis, "production planning" can be defined as: determining the best way to use production resources efficiently to balance productivity and product demand over time and to ensure that production plans are consistent with the strategic goals and objectives of the organization. In other words, it is a functional planning process at the level of production departments or divisions within an organization. It includes a range of activities and methods designed to organize and prepare production factors (such as people, machinery, raw materials, and capital) to produce specific goods to specifications and at the lowest possible cost within a specified time limit.

2.1 . The Importance of Production Planning

The importance of production planning is highlighted through the following points[2]:

1. It focuses on operations, within a unified framework that encompasses all products and production lines.
2. It aligns with the company's strategies and the objectives it aims to achieve.
3. It avoids delving into details that could hinder the planning process, making it complex and difficult to follow.
4. It allows for the aggregation or summarization of products, services provided, required effort, labor, and necessary working hours.
5. The annual management plan is established by senior management, outlining the annual budget and the company's strategic objectives. The aggregate and detailed plans derive their requirements from this framework.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

6. The "Master Production Schedule (MPS) " specifies the timing and quantities of production for each product within a product family.

2.2.Objectives of Production Planning

Through production planning, an organization seeks to achieve several objectives. Since the functional areas that provide input to the production plan often have conflicting goals regarding the use of organizational resources, it is essential to address these various objectives. Among these objectives are[6]:

1. Reducing Costs and Increasing Production : Minimizing expenses while maximizing output.
2. Maximizing Customer Service.: Improving delivery times may require additional workforce, machinery, or increased inventory.
3. .Reducing Inventory Investment.: Accumulating inventory can be costly, and funds could be allocated to more productive investment areas.
4. .Minimizing Fluctuations in Production Rates.: Frequent changes in production rates can create difficulties in coordinating material preparation, necessitating rebalancing of the production line.
5. .Reducing Fluctuations in Workforce Levels.: Variability in workforce levels can lead to decreased productivity, as new employees typically require time to become more efficient.
6. .Maximizing Plant and Equipment Utilization.: Operations based on linear flow require consistent and high investment in plant and equipment to ensure optimal utilization.

2.3 .Types of Production Plans.

Three types of production planning can be distinguished within an organization, as follows[3]:

1. .Long-Term Production Planning.:

This involves determining production levels for future periods exceeding two years, potentially extending to several years. It focuses on defining the necessary capacity for which top management is responsible, as it pertains to required production facilities, expansion, product development, financing, and investment. Long-term plans may cover a period of 3 to 10 years and are typically updated annually. These plans are at the corporate level and consider all factories and products. Their inputs include long-term aggregate forecasts and available plant capacity[9].

Long-term planning may lead to one or two scenarios:

a. .Surplus in Current Production Capacity.:

In this case, it may be appropriate to utilize the excess capacity by producing a new product, or it may be better to sell, dispose of, or delay the use of the excess capacity.

b. .Shortage in Current Production Capacity.:

In this scenario, the best option must be sought, which may involve purchasing machinery and equipment, hiring more workers, or both.

2. .Medium-Term Production Planning.:

This covers a period of 6 months to 2 years, with monthly or quarterly updates. Typical plans are for one year with monthly updates. Input includes capacity and product decisions derived from the long-term plan. Part of this plan

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

may involve determining the processes used for each product family, production rates, and inventory levels. These decisions determine the required quantities of raw materials and allow for contracting capacity with multiple suppliers.

3. .Short-Term Production Planning.:

These plans are developed to cover periods ranging from one week to 6 months, with daily or weekly updates. A common time limit is one month with weekly updates. This type of plan specifies the time required to manufacture a specific product on a particular machine. It also flags things like overtime, time shortages, and the odds of falling short on meeting all the demand. Plus, it gives suppliers clear directions on exactly how much to deliver and when to drop it off [11]

Table (1): Timelines, Quantities, Resources, and Choices for Each Plan

Aspect	Long-Term Plan	Medium-Term Plan	Short-Term Plan
Time limit	3–10 years	6 months – 3 years	1 week – 6 months
Units	Dollars, hours	Dollars, hours, product lines, product families	Products, product families (product family)
Inputs	Aggregate forecast, plant capacity	Medium-term forecast, production and capacity levels derived from the long-term plan	Short-term forecast, workforce levels, operations, inventory levels
Decisions	Capacity, product, supplier requirements, quality policies	Workforce levels, inspections, production equations, inventory levels, contracts with suppliers, quality levels and costs	Work allocation to machines, overtime, subcontracting, delivery schedules, product quality

2.4 Steps of Production Planning

Production planning is an ongoing process that keeps in step with everything an organization's already doing. To ensure that this plan is well-prepared and effective, enabling the organization to derive maximum benefit, the process of developing an aggregate production plan involves the following steps[4]:

1 .Identifying Product Groups and Dividing the Medium-Term Planning Horizon. :

The planning horizon (typically one year) is divided into shorter time periods (e.g., monthly intervals), and product groups are defined.

2 ..Preparing Demand Forecasts. :

A forecast of estimated demand is prepared for each product group and each time period within the plan. These demand forecasts are then translated into specific resource requirements (e.g., labor needs).

3 .Managing Demand Fluctuations. :

If demand varies significantly from one period to another, alternatives such as price adjustments, promotional programs, and other strategies are employed to influence the level and timing of product demand.

4 .Comparing Current Capacity with Required Capacity. :

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

The current production capacity is compared with the capacity needed to fulfill orders in each time period of the plan. If there is a mismatch between required and available capacity, alternatives for adjusting capacity are considered, and the cost of each alternative is estimated.

5 ..Selecting an Aggregate Planning Strategy. :

Developing an acceptable plan is an iterative process. Plans often require multiple revisions and adjustments. The plan must be scrutinized under existing constraints and evaluated against organizational goals. Once finalized, the plan should be approved by representatives from all functional departments (e.g., marketing, finance, strategy, etc.).[16]

It is important to note that the process of preparing an aggregate production plan is ongoing. It begins with demand identification through forecasting, considering the organization's production capacity, external environmental conditions, and competitive factors. Subsequently, alternatives, relationships, and constraints are defined. The organization has several alternatives related to demand and capacity, such as adjusting product prices, hiring additional workers, or reducing the workforce. Constraints governing the relationships between various elements of the plan are also identified.[5]

Based on the above, the organization prepares a projected plan. If the plan is acceptable and aligns with the organization's objectives, a decision is made to implement it. If the plan is not acceptable, the organization must revisit the alternatives, relationships, and constraints that were initially established.

3. De Novo Programming

The De Novo Institution programming" method is a mathematical tool for identifying solutions (alternatives to a problem) that allows the user to allocate the organization's available resources between different uses and select the best solution from the practical options. The chosen solution can be considered optimal because the optimal solution determined using the ab initio programming method in a manufacturing organization shows the decision maker how much of each product under study should and should not be produced. This method allows the organization to work toward its goal of boosting the production line while keeping costs as low as possible. Linear programming models, which have been some of the most popular tools in operational research since they were first developed, are great for tackling problems with a single focus—like cutting costs or increasing profits—to meet specific targets in the most effective way. This study is all about improving the production line to help industrial organizations (the ones we're looking at here) make the most profit possible, all while keeping expenses down and making smart use of the resources, time, and skills they already have. To do this, we're using something called the 'De Novo programming' approach to upgrade the production line and help the organization earn bigger profits without spending more than necessary.

De Novo programming is a pretty cool approach—it's all about building fresh algorithms or strategies from scratch to tackle tricky optimization challenges. It opens up an exciting path for digging deeper in academic discussions and computational science, pushing the boundaries of what traditional optimization methods can do.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

De Novo programming stands out because it's got some real advantages over the usual decision-making models, which often force you to pick one goal over another. Instead of making those tough trade-offs, De Novo programming tries to hit all the key targets at once by figuring out the best way to use resources and streamline the production process. The result? It can seriously boost productivity and efficiency for organizations. Traditional models tend to zero in on one thing—like profits—and let the other goals slide, but De Novo takes a broader view, aiming for solutions that shine across the board. That leads to outcomes that feel more balanced and practical, which is a big win for making smarter choices in production management. Oh, and this approach also goes by the name 'Multi-Criteria Solution Procedure (MCSP)' [6].

On top of that, De Novo programming doesn't just make things run smoother computationally, it also makes the results easier to understand, which is a hurdle a lot of optimization methods struggle to clear. Traditional techniques can be so murky that people hesitate to use them in high-stakes areas like healthcare, finance, or logistics. That's why digging into the academic research on De Novo programming is so appealing: it's about finding top-notch solutions that don't leave you scratching your head when you try to figure out what they mean in tricky, real-world situations.

At its core, De Novo programming is all about designing systems that lift productivity across multiple goals. It looks at the whole optimization puzzle—not just picking the best solution but also figuring out how to make the most of resources within a set budget, even when moneys tight. That's necessary when you're putting together a De Novo plan.

What's cool is that De Novo programming sets up the constraints so that every resource gets used to the fullest—no waste, no leftovers. And here's the kicker: you can still use it even if you don't know all the limits or boundaries of your multi-objective problem if you've got the cost per unit of resources and the total budget nailed down. Plus, it treats every goal with the same weight, giving you equal target values so no objective gets left behind. That way, everything you're aiming for gets the attention it deserves.

1.1. Choosing de novo programming over traditional methods

The de novo programming model was chosen over goal programming or linear programming because it improved production at the Al-Dhahabi Dairy Plant in a way that includes optimizing budget utilization and can account for price changes and achieve the highest possible profit, making it ideal for the Al-Dhahabi Dairy Plant where raw material prices change constantly. While linear programming and goal programming offer a limited solution because they treat raw materials as fixed.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Table (2): shows the actual differences between De novo programming, Linear programming and Goal programming

Model	Taking advantage of discounts	Flexibility in dealing with prices	Budget	Achieving profitability	Raw materials
De novo programming	Fully supports discounts	Happens automatically with budget allocation	Important element	Highest profitability	Variable
Linear programming	Does not support discounts	Does not support flexibility	Not important	Average	Fixed
Goal programming	Can be utilized but requires additional models	Supports but is complex	Not important	Average to high	Fixed

1.2. Building and Solving a Linear Programming Model Using De Novo Programming.

A multi-objective problem is one of those optimization puzzles where you've got to juggle more than one goal at the same time to figure out the best solution. The catch? These goals often clash—boosting one might mean dragging another down, so you're stuck navigating trade-offs. Here's what makes up a multi-objective problem:

1. **Objective Function**:
   This is the math formula that spells out what you're trying to optimize. It's the thing you're either trying to crank up to the max or dial down to the minimum, depending on the problem.
2. **Constraint Function**:
   Constraints are the rules of the game—math expressions that limit what your decision variables can do. They might be equalities or inequalities, and they can get pretty fancy with linear or nonlinear twists tied to those variables.
3. **Decision Variables**:
   These are the key players—the variables you're tweaking to get the best outcome. They're what the objective function hinges on, and they've got to play by the constraints you've set.

Using optimization for these multi-objective challenges has opened the door to tackling tougher issues across all sorts of fields. You see it popping up everywhere—product portfolio planning, computational design, vehicle routing, land use management, closed-loop supply chains, transportation networks, home healthcare, and even multi-energy systems.

In tech, optimization helps us build smarter systems by weighing stuff like cost, safety, and energy use. In manufacturing, it's a lifesaver for companies aiming to churn out top-notch products without breaking the bank. In economics, it's all about making the most of resources while balancing growth, environmental impact, and people's needs. In business, it keeps the supply chain humming efficiently. Basically, multi-objective optimization is like a superpower for making smarter, more sustainable calls by keeping all these factors in play at once.

Now, in the world of optimization, this guy Zeleny [7] came up with a neat twist: turning multi-objective problems into something called De Novo programming.

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Max $z = \sum_{j=1}^{n} s_j x_j - \sum_{i=1}^{m} p_i b_i - \sum_{k \in K} p_{k'} d_k$

s.t

$$a_{11}x_1 + a_{12}x_{2+\cdots+}a_{1n}x_n = b_1$$
$$a_{21}x_1 + a_{22}x_{2+\cdots+}a_{2n}x_n = b_2$$
$$a_{m1}x_1 + a_{m2}\,x_2 + \ldots\ldots + a_{mn}\,x_n = b_m$$
$$p_1 b_1 + p_2\,b_2 + \ldots\ldots + p_m\,b_m \leq B$$
$$x_{ij},\ b_i,\ d_i \geq 0$$

These equations represent the relationship between products (xj) and raw materials (bj), where a_{ij} is the quantity of raw material i required to produce one unit of product j.

There are three constraints:

1.Raw Material Constraints.

2.Production Constraints.

3.Budget Constraint.

The symbols used in constructing the .De Novo programming. model can be defined as follows :

Z: Represents the total profit that the plant aims to achieve .

x_i: Represents the quantities to be produced, such as (milk, cheese, cream, whey.

s_j: Represents the price per unit of milk, cheese, cream, or whey .

a_{ij}: Represents the quantity of resources required to produce one unit of product .j. In other words, if . a_{ij} represents the quantity of milk needed to produce one unit of milk .

b_i : A set of decision variables representing the level of resource .i. to be purchased .

p_i: Represents the purchase price of resource .i., such as (milk, butter, etc.) .

$p_{k'}$: Represents the change in the purchase price of resources .k.

d_i: Represents additional materials .

B: Represents the total budget available for the specified system.

4. Al-Dhahabi Dairy Plant and Its Structure:

The journey of Al-Dhahabi Dairy Plant began at the pinnacle, as the plant was established in 2020 and commenced operations on June 23, 2021, with a paid-up capital of 150 million Iraqi dinars. Al-Dhahabi Dairy Plant is the second private dairy plant to open in Nineveh Governorate, following Al-Jazeera Dairy Plant, the first of its kind in the region. Throughout its history, the plant has undergone a series of transformations and changes. Initially, it emerged as the second dairy plant, engaging in commercial activities among numerous dairy plants in Nineveh Governorate. The year 2022 marked a significant turning point in the history of dairy production in the governorate. The plant aims to contribute to national, economic, and financial support, in addition to its core activity of accumulating funds and investing them in supporting mall owners, markets, and small shops. "Al-Dhahabi Dairy Plant in Nineveh Governorate really shines as a key player in the local dairy scene. It pumps out a tasty lineup—milk,

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yogurt, cream, cheese, and whey—and does a lot to keep the area's economy buzzing. On top of that, it's a lifeline for plenty of people around here, providing solid jobs and keeping things humming with several key departments that all chip in to make its range of products happen. Plus, it doesn't just stop at its own walls, it offers all kinds of support to other plants across the governorate. Its distribution network stretches everywhere, getting goods to traders, mall owners, and even the smallest retail shops, with a handful of companies handling deliveries to markets, malls, and corner stores alike.

Here's how it all comes together inside the plant:

1. **Milk Reception Department**:
   This is where it all starts—they bring in raw milk from local farms and give it a thorough check to make sure it's top-quality and clean before kicking off production.
2. **Pasteurization Department**:
   Here, the milk gets heated up exactly right to zap any nasty bacteria, making sure everything's safe and ready to go.
3. **Production Department**:
   This is the heart of the operation, with different lines cranking out yogurt, cheese, cream, whey—you name it.
4. **Packaging Department**:
   Once everything's done, this crew packs it all up into the right containers and seals them tight so the products stay safe on their way out the door.
5. **Storage Department**:
   They've got this spot dialed in for keeping raw materials, cartons, and packaging stuff organized and ready whenever the finished goods need them.
6. **Quality Control Department:**
   This department ensures that all products comply with quality and safety standards by conducting regular tests and sample inspections
7. **Maintenance Department:**
   This department is tasked with maintaining machinery and equipment to ensure their efficient operation and prevent any production downtime.
8. **Distribution Department:**
   This department manages the distribution of products to local markets, retail stores, and consumers.

5. Practical application:

At the Golden Dairy Factory, we've put the De Novo programming model to work on tackling our production planning challenges. We gathered all the data we needed from the factory's digital records and stats. This place churns

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out eight diverse types of dairy products—check out Table No. 2 for the full rundown. That table also shows the lowest production prices we can hit, plus the fact that everything we make has a 30-day window to sell.

Table (3): Names of Produced Products

Product Name / Package	Production Quantity (Minimum) / Package	Selling Price / IQD
Yogurt (1500 g package)	1800	1625
Yogurt (750 g package)	300	950
Yogurt (650 g package)	1100	850
Yogurt (300 g package)	400	400
Cream	4800	200
Cheese (100 g package)	4400	200
Glass Cheese (130 g package)	3000	425
Shanina (Drinkable Yogurt)	4900	150

The plant whips up a bunch of dairy goodies—yogurt, cream, cheese, and whey—and each one comes with its own minimum production target, like you can see in the table up there. These are the baselines we've got to hit to keep things financially solid. Prices shift depending on what you're buying and how much of it—like a 1500-gram tub of yogurt, which goes for 1,625 Iraqi dinars, making it the priciest yogurt option. Cream and cheese, on the other hand, are a bit cheaper, which makes sense since we need to move bigger batches of those. Digging into all this will help us figure out which products bring in the most cash.

One tricky part is keeping production and demand coordinated. Stuff like cream and whey, which have high minimum outputs, might need some smart marketing to make sure everything sells. Looking at production caps and selling prices, we've got to keep an eye on what the market wants and tweak how much of each product we're making—no one wants a pile of unsold goods or empty shelves. Boosting the marketing for slower movers like cream or cheese could really lift our overall revenue. The plant should also track what each product costs to make versus what it pulls in, so we can pinpoint the real money-makers and lean into those.

Additionally, table (4) presents a list of raw materials and additives used in the production of yogurt, cheese, cream, and whey. There are (18 different raw materials), and the table includes the purchase price for each material, as shown in the following table:

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Table (4): Prices of Raw Materials and Additives

Raw Material / Additive	Milk b1	Butter Substitute b2	Gelatin b3	Starch b4	Zer Butter b5	Zer Butter d5	Butter Flavor b6	Whey Starter b7	Whey Starter d7	Spanish Cream Flavor b8	Wadi Cheese Flavor b9
Unit Price (IQD)	3120	2220	9000	935	10500	10000	28000	11500	11000	52250	32000
Raw Material / Additive	Baking Soda b10	CMC Stabilizer b11	CMC Stabilizer d11	Natamycin b12	Nisin b13	Sugar b14	Caustic Soda b15	Caustic Soda d15	Almond Oil b16	Maysa Yogurt Starter b17	Cream Flavor b18
Unit Price (IQD)	1775	12600	12650	71850	71500	1100	2240	2260	1200	28000	34000

Table (4) presents a list of raw materials and additives used in the production of dairy products, cheese, cream, and whey at the plant. The table includes (18) different raw materials, along with the unit cost for each material. The plant relies on a variety of raw materials, including basic products such as milk (3,120) IQD, butter substitute (2,220) IQD, gelatin (10,500) IQD, and additives that enhance flavor or product stability, such as butter flavor (28,000) IQD, CMC stabilizer (12,650) IQD, and caustic soda (2,260) IQD. The raw materials range from natural products like milk and butter to chemical or synthetic substances such as CMC stabilizer and caustic soda.

The plant should explore ways to reduce raw material costs without compromising product quality. This may include searching for lower-cost alternatives for certain materials or negotiating with suppliers to obtain better prices. A chart illustrating the costs of raw materials is provided.

Additionally, table (5) includes the quantity of raw materials required per unit of each product (a_{ij}), which is also used in the production planning problem. These values are presented in the following table[89]:

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Table (5): Components of Each Product from Raw Materials

Product Name	Yogurt (1500g)	Yogurt (750g)	Yogurt (650g)	Yogurt (300g)	Cream	Cheese (100g)	Glass Cheese (130g)	Shaneena
Milk	1.5	0.75	0.65	0.3	0.2	0.1	0.13	0.2
Butter Substitute	0.5	0.3	0.2	0.1	0.3	0.4	0.25	0.1
Gelatin	0.2	0.1	0.1	0.05	0.3	0.2	0.15	0.1
Starch	0.1	0.05	0.05	0.02	0.2	0.15	0.1	0.05
Zeer Butter	0	0	0	0	0.25	0.3	0.2	0.15
Butter Flavor	0	0	0	0	0.35	0.4	0.3	0.25
Shaneena Starter	0.18	0.15	0.1	0.08	0	0	0	0.3
Spanish Cream Flavor	0.15	0.1	0.08	0.05	0.2	0.15	0.1	0
Wadi Cheese Flavor	0.25	0.2	0.15	0.1	0.3	0.25	0.2	0
Baking Soda	0.2	0.15	0.1	0.08	0	0.1	0.15	0.1
CMC Stabilizer	0.1	0.08	0.05	0.03	0.2	0.15	0.1	0
Natamycin	0.3	0.25	0.2	0.15	0.35	0.3	0.25	0
Nisin	0.2	0.15	0.1	0.08	0.25	0.2	0.15	0
Sugar	0.5	0.4	0.3	0.2	0.4	0.35	0.3	0.25
Caustic Soda	0.05	0.04	0.03	0.02	0.05	0.04	0.03	0
Lemon Dizzy	0.15	0.13	0.1	0.08	0.2	0.15	0.1	0.08
Maysa Yogurt Starter	0.2	0.15	0.1	0.08	0.25	0.2	0.15	0.1
Cream Flavor	0	0	0	0	0.35	0.4	0.3	0.25

The table's a handy tool for keeping an eye on the resources we're using in production, making sure we're getting the most out of them and that we've got enough on hand to keep the production line humming. By knowing exactly how much raw material each product needs, the plant can fine-tune how much we use, cut down on waste, and boost efficiency while trimming those operational costs. Tracking the amounts of each material we go through helps us avoid either burning through too much or not using enough, which is a big win for keeping waste in check.

On top of that, the table's a lifesaver for planning purchases and figuring out the budget we'll need for each production run, based on what each product calls for. It also keeps production on track by spelling out exactly how much of each raw material every product requires. With this setup, management can nail down raw material needs with confidence. And since the table lists those quantities, it's a breeze to calculate what each product costs to make based on the materials we're using—giving us a clear picture of profitability.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Table (6): Monthly Production Totals

Variables	X1	X2	X3	X4	X5	X6	X7	X8	Milk
Optimal _solution-Quantities	102.372	100.131	103.029	99.383	108.079	103.551	99.437	104.116	97,683
Variables	Butter Substitute	Gelatin	Starch	Zer Butter	Zer Butter	Butter Flavor	Whey Starter	Whey Starter	Spanish Cream Flavor
Optimal _solution-Quantities	72,814.10	56,244.45	41,391.50	41,391.50	110,007	93,582.35	71,385.05	72,760	54,919.05
Variables	Wadi Cheese Flavor	Wadi Cheese Flavor	Baking Soda	CMC Stabilizer	Natamycin	Nisin	Sugar	Caustic Soda	Caustic Soda
Optimal _solution-Quantities	12,472.70	170	6,865	206	6,084	3,045	34,687.98	6,780	0
Variables	Almond Oil	Maysa Yogurt Starter	Cream Flavor	Y1	Y2	Y3	Y4	Z*	
Optimal _solution-Quantities	5,530	54,673.60	35,240.60	1	0	0	1	7,561,686.50	

6. General Model Formulation:

- **Objective Function: Maximize Profit**

Through the de novo programming model, an optimal system design can be created with the following important formulation:

$$\text{Maximize } z = 1650x_1 + 950x_2 + 850x_3 + 400x_4 + 200x_5 + 200x_6 + 425x_7 + 150x_8 - (3120b_1 + 2220b_2 + 9000b_3 + 935b_4 + 10500b_5 + 28000b_6 + 11500b_7 + 52250b_8 + 32000b_9 + 1775b_{10} + 12600b_{11} + 71850b_{12} + 71500b_{13} + 1100b_{14} + 2240b_{15} + 1200b_{16} + 28000b_{17} + 34000b_{18}) - (10000d_5 + 11000d_7)$$

1. Raw Material Constraints:

- For milk:

$$1.5x_1 + 0.75x_2 + 0.65x_3 + 0.3x_4 + 0.2x_5 + 0.1x_6 + 0.13x_7 + 0.2x_8 - b_1 \geq 0$$

- For substitute butter:

$$0.5x_1 + 0.3x_2 + 0.2x_3 + 0.1x_4 + 0.3x_5 + 0.4x_6 + 0.25x_7 + 0.1x_8 - b_2 \geq 0$$

- Gelatin:

$$0.2x_1 + 0.1x_2 + 0.1x_3 + 0.05x_4 + 0.3x_5 + 0.2x_6 + 0.15x_7 + 0.1x_8 - b_3 \geq 0$$

- Starch:

$$0.1x_1 + 0.05x_2 + 0.05x_3 + 0.02x_4 + 0.2x_5 + 0.15x_6 + 0.1x_7 + 0.05x_8 - b_4 \geq 0$$

- Low-fat butter:

$$0.25x_1 + 0.3x_2 + 0.2x_3 + 0.15x_4 - b_5 \geq 0$$

- Butter flavor:

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

$0.35x_1 + 0.4x_2 + 0.3x_3 + 0.25x_4 - b_6 \geq 0$

- Sour cream starter:

$0.18x_1 + 0.15x_2 + 0.1x_3 + 0.08x_4 + 0.3x_5 - b_7 \geq 0$

- Spanish cream flavor:

$0.15x_1 + 0.1x_2 + 0.08x_3 + 0.05x_4 + 0.2x_5 + 0.15x_6 + 0.1x_7 - b_8 \geq 0$

- Wadi cheese flavor:

$0.25x_1 + 0.2x_2 + 0.15x_3 + 0.1x_4 + 0.3x_5 + 0.25x_6 + 0.2x_7 - b_9 \geq 0$

- Food grade soda:

$0.2x_1 + 0.15x_2 + 0.1x_3 + 0.08x_4 + 0.1x_5 + 0.15x_6 + 0.1x_7 - b_{10} \geq 0$

- Stabilizer:

CMC $0.1x_1 + 0.08x_2 + 0.05x_3 + 0.03x_4 + 0.2x_5 + 0.15x_6 + 0.1x_7 - b_{11} \geq 0$

- Natamycin:

$0.3x_1 + 0.25x_2 + 0.2x_3 + 0.15x_4 + 0.35x_5 + 0.3x_6 + 0.25x_7 - b_{12} \geq 0$

- Nisin:

$0.2x_1 + 0.15x_2 + 0.1x_3 + 0.08x_4 + 0.25x_5 + 0.2x_6 + 0.15x_7 - b_{13} \geq 0$

- Sugar:

$0.5x_1 + 0.4x_2 + 0.3x_3 + 0.2x_4 + 0.4x_5 + 0.35x_6 + 0.3x_7 + 0.25x_8 - b_{14} \geq 0$

- Caustic soda:

$0.05x_1 + 0.04x_2 + 0.03x_3 + 0.02x_4 + 0.05x_5 + 0.04x_6 + 0.03x_7 - b_{15} \geq 0$

- Lamondzi:

$0.15x_1 + 0.13x_2 + 0.1x_3 + 0.08x_4 + 0.2x_5 + 0.15x_6 + 0.1x_7 + 0.08x_8 - b_{16} \geq 0$

- Maisa yogurt starter:

$0.2x_1 + 0.15x_2 + 0.1x_3 + 0.08x_4 + 0.25x_5 + 0.2x_6 + 0.15x_7 + 0.1x_8 - b_{17} \geq 0$

- Cream flavor:

$0.35x_1 + 0.4x_2 + 0.3x_3 + 0.25x_4 - b_{18} \geq 0$

2. Minimum Production Constraints:

$x_1 \leq 1800,\ x_2 \leq 300,\ x_3 \leq 1100,\ x_4 \leq 400,\ x_5 \leq 4800,\ x_6 \leq 4400,\ x_7 \leq 3000,\ x_8 \leq 4900$

3. Budget Constraint:

$3{,}120b_1 + 2{,}220b_2 + 9{,}000b_3 + 935b_4 + 10{,}500b_5 + 10{,}000d_5 + 28{,}000b_6 + 11{,}500b_7 + 11{,}000d_7 + 52{,}250b_8 + 32{,}000b_9 + 1{,}775b_{10} + 12{,}600b_{11} + 12{,}650d_{11} + 71{,}850b_{12} + 71{,}500b_{13} + 1{,}100b_{14} + 2{,}240b_{15} + 2{,}260d_{15} + 1{,}200b_{16} + 28{,}000b_{17} + 34{,}000b_{18} \geq 200{,}675{,}000$

4. Conclusion:

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

Consolidated Optimal Solution Table

Table (7): Monthly Production Totals

Variable	Description	Optimal Quantity
X1	Product 1	102.372
X2	Product 2	100.131
X3	Product 3	103.029
X4	Product 4	99.383
X5	Product 5	108.079
X6	Product 6	103.551
X7	Product 7	99.437
X8	Product 8	104.116
b1	Milk	97,683
b2	Substitute Butter	72,814.1
b3	Gelatin	56,244.45
b4	Starch	41,391.5
b5	Low-fat Butter	41,391.5
b5 (2)	Low-fat Butter (additional)	110,007
b6	Butter Flavor	93,582.35
b7	Sour Cream Starter	71,385.05
b7 (2)	Sour Cream Starter (additional)	72,760
b8	Spanish Cream Flavor	54,919.05
b9	Wadi Cheese Flavor	12,472.7
b9 (2)	Wadi Cheese Flavor (additional)	170
b10	Food Grade Soda	6,865
b11	CMC Stabilizer	206
b11 (2)	CMC Stabilizer (additional)	0
b12	Natamycin	6,084
b13	Nisin	3,045
b14	Sugar	34,687.98
b15	Caustic Soda	6,780
b15 (2)	Caustic Soda (additional)	0
b16	Lamondzi	5,530
b17	Maisa Yogurt Starter	54,673.6
b18	Cream Flavor	35,240.6
y1	Binary Decision Variable 1	1
y2	Binary Decision Variable 2	0
y3	Binary Decision Variable 3	0
y4	Binary Decision Variable 4	1
z*	Optimal Objective Function Value	7,561,686.5

The table includes:

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

- Product variables (X1-X8)
- Raw material variables (b1-b18) including those with additional quantities
- Binary decision variables (y1-y4)
- The optimal objective function value (z^*)

From table (6) These results indicate a high efficiency of applying the proposed model using De Novo programming in solving the problem of optimizing the production plan in various production companies. By using the De Novo approach, most diverse cases can be handled more effectively compared to traditional programming models. In this paper, the investigation focused on rising raw material costs and quantity discounts for certain raw materials in the production of Al-Dhahabi Dairy Factory. The aim of this analysis is to demonstrate the best production strategy for Al-Dhahabi Dairy Factory, in terms of optimal quantities for each product, and how to distribute and use resources in a way that maximizes profit. This helps management make better decisions related to production and purchasing based on available resources and prices, which enhances profitability and reduces costs. Through this analysis, a balance is achieved between production costs and returns, ensuring that the factory operates with maximum possible efficiency to achieve maximum profit. Finally, it presents the results of applying the De Novo model to optimize production. Through it, the optimal production quantities of each product are determined to ensure the highest possible profit, considering the costs related to raw materials and how to manage resources intelligently.

You know, the results from using the De Novo programming model at Al-Dhahabi Dairy Plant are impressive. It's like they finally found a way to make everything click—production's running smoother, and they're getting way more bang for their buck. This isn't just about making more money, though that's definitely a perk. It's also about getting a grip on costs, giving the whole operation some breathing room to adapt, and keeping things firing on all cylinders.
For the longest time, they were wrestling with this tricky balance—making sure what they churned out lined up with what people wanted to buy. And the waste? Oh man, raw materials were practically disappearing into thin air. But then De Novo came along, and it's like someone handed them a cheat sheet. They nailed down exactly how much of everything they need, and now waste is barely even a blip on the radar. It's smart, it saves cash, and honestly, it feels like this model was tailor-made for a place like the dairy plant.

The numbers tell the story: we landed on ideal production figures like 102.37 units of 1500-gram milk and 108.08 units of cream. These amounts hit demand square-on without overdoing it, keeping surplus to a minimum. Key resources—think milk, butter, and starch—were used smartly, never going over the max limits. We're talking 97,683 liters of milk and 72,814.1 units of butter substitute, all consumed with no leftovers or shortages. The payoff? A tidy profit of 7,561,686.5 Iraqi dinars, showing how well this model ramps up productivity while keeping costs low—without skimping on quality.

What's great about De Novo is how it helps the plant roll with the punches, whether its shifting market demands or resource price swings. That flexibility makes the production line more adaptable and gives the plant a competitive edge. With a budget of 200,675,000 Iraqi dinars, costs were covered and spread out efficiently based on what each

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

material needed, even leaving some wiggle room to manage pricier stuff like butter flavoring. On top of that, the model helped us grab some raw materials at lower prices whenever those deals popped up. It used things like Y1 and Y4 to spot those discounts during purchasing, which let us cut down on production costs and stay flexible when prices swung up or down. With this setup, our budget stretched further—it focused on the right priorities to keep costs in check and make sure we didn't go over budget.

Given all this, I'd strongly suggest Al-Dhahabi make De Novo programming its go-to tool for planning production and managing resources moving forward. It's proven it can juice up profits, cut expenses, and set the plant up for long-term success. On top of that, it's worth pouring some effort into shaking up the production process and dreaming up new products. Producing fresh or improved dairy items that match what the market's craving could boost sales and solidify the plant's spot in the game.

With those optimal quantities in hand, setting up a sharp inventory system makes sense—stocking just what we need and nothing more. That'll keep storage costs low and dodge surplus or shortages. It'd also be smart to haggle with suppliers for bulk discounts, especially on big-ticket items like milk and butter—buying in bulk could shrink costs and fatten up profit margins.

De Novo reach could go beyond production, too—think storage, distribution, even sales management. It'd tie together all the plant departments for a smoother, more efficient operation. And since prices and demand can shift, I'd recommend regularly checking cost data and production limits to keep the model fresh and dialed in to whatever's new, so the plant stays ahead of the curve. Oh, and don't sleep on marketing—pushing products like cheese and cream that aren't flying off the shelves could move those quantities, cut surplus risks, and shore up the plant's finances. Overall, De Novo is a tool that can lift every part of the operation, tying it all together for top-notch efficiency.

Funding

None

Acknowledgement

None

Conflicts of Interest

The author declares no conflict of interest.

EISSN: 3005-3625, PISSN: 2790-2560, DOI: http://doi.org/10.58564/EASJ/4.4.2025.9

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