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CONSIDERING DIFFERENT TYPES OF CONSTRAINTS FOR PRODUCTION PLANNING FOR A DAIRY PRODUCT: A CASE STUDY

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Abstract

Dairy industry plays a critical role in the economics of many countries. Recently, dairy companies have faced challenges in Iran due to their present position and new governmental policies. In this paper, a dairy company which has the significant market share in Iran is chosen. Despite having a variety of products which are manufactured in this company, yoghurt is selected due to its attractiveness in Iranian food habits. Therefore, this company is looking for a production planning which helps it gain a considerable profit and boost its current market share. For this reason, a linear programming model is formulated and the obtained results show that profit achieved by this model is higher than those obtained in the last years.

Key Words: Dairy industry; Production planning; Yoghurt; Iran

INTRODUCTION

Household spending investigation in Iran depicts that people spend a significant amount of money for dairy products. Research has shown that one of the dairy products that Iranian people often eat along their main course is yoghurt. Many diary companies were established in Iran and are selling their products all over the country. Therefore, dairy product market is intensively competitive. These companies quest new methods to differentiate themselves from others and expand their market share. New bills which are passed in Iranian parliament have also engendered new concerns for these companies and caused the price of yoghurt material to be raised significantly in a condition that these companies are still forced not to increase the selling prices of their products. Therefore, diary companies are looking for new polices to soothe this situation and encounter efficiently with this wealth of challenge. In this paper, one of Iranian diary companies called here X Company is studied .The owners of X Company are reluctant that the name of their company is stated directly. X Company is an Iranian leading diary company which produces different types of products such as milk, ice cream, cheese, butter and yoghurt. Since yoghurt is considered as a strategic product for this company, it is investigated in this paper. 25 types of yoghurt are produced in X Company and each has its own demand. Since milk is the core raw material of yoghurt and it plays a critical role in its production, milk management is considered a critical factor but a complex task which is noticed in this paper. All types of yoghurts are categorized into 9 groups on the basis of their weights. Since the diversity of yoghurt types and market competitive condition is being noticed by this company and this company also struggles with production planning and processing due to the quantity and quality of its main raw material i.e. milk, a production planning optimization is considered for this company to help it not to hinder from its competitors and gain a considerable profit. In other words, X Company is going to acquire a production planning which helps it gain profit in this tender condition, become more efficient and easily control the behaviors of other manufactures. This paper is organized as follows: in the next section, the related studies found in literature are presented. Section III describes the problem and provides the mathematical model. The results of this study are discussed in section IV. Section V includes the main finding and future research avenues.

THEORETICAL BACKGROUND

Developing mathematical models for maximizing the profit is the method which has been utilized in many different industries. Ioannou (2005) developed appropriate

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transportation models to achieve optimal distribution practices in sugar industry. The optimal solution of the respective model led to saving of approximately one million dollars and improved demand coverage. Blanco et al .(2005) generated a model for a packaging plant operating with one processing line, seven types of fruit and 20 final products. The mentioned model is also useful in fruit industry. But the issue in dairy industry is a little bit distinct. The majority of researches which are done in this industry did not pursue the profit maximization quantitatively. They just offered some theories to raise the efficiency and effectiveness of the industry. Sankaran et al. (2003) followed the strategy of cost leadership and then reviewed the various ways to boost the efficiency of dairy industry logistics in New Zealand. Rakotoarisoa et al. (2006) measured the competitiveness of India's dairy industry and they found that they should increase the productivity and efficiency of milk production and milk processing in order to be successful. Therefore the shortage of quantitative study in dairy industry is felt. Guan et al. (2009) offered a multistage stochastic programming to a production planning problem for a dairy company in New Zealand and considered uncertain milk supply, price-demand curves and contracting. In this paper, an Iranian leading dairy company which produces a variety of products is taken into account. A model is developed for profit maximization of one of its products, "yoghurt". In other words, this model aims at presenting a yoghurt production planning that considers all aspects such as demands, sales, production equipment and etc.

MODEL DESCRIPTION

The X Company has the production lines of yoghurt, milk, cream, ice cream, cheese and other dairy products. Yoghurt family has 25 different products which are categorized into 9 groups according to their weights. Different types of yoghurts are illustrated at the Table 1.

Table 1-The Yoghurt Products of X Company

The X Company aims at maximizing its profit within one year time horizon and with respect to existing constraints which are discussed at the following.

If the number of products which is produced belongs to group j and month t, it is defined as x_{ijt}. The product profit i of group j is also considered as p_{ij}. Therefore, the objective function is written as follows:

$$Max \sum_{i=1}^{n_j}\sum_{j=1}^{9}\sum_{t=1}^{12} x_{ijt}\cdot p_{ij} \quad (1)$$

In this formula, n_j is the number of existing products in group j.

The model constraints are divided into three categories of production, product sales and top management policies.

The production constraints

The consumed milk constraint

Since the amount of milk used for producing the whole products is limited and deterministic and with regard to this fact that the company produces other products, top management considers an upper bound for milk which is used for yogurt production in each month and it is illustrated by u. The consumed milk is also limited for each product group and it is depicted by UM_j:

$$\sum_{i=1}^{n_j}\sum_{j=1}^{9} x_{ijt}\cdot w_j\cdot c_{ij} \le U \quad for\ t = 1,2,\dots,12 \quad (2)$$

$$\sum_{i=1}^{n_j} x_{ijt}\cdot w_j\cdot c_{ij} \le UM_j \quad for\ t = 1,2,\dots,12\ and\ j = 1,2,\dots,9 \quad (3)$$

In this formula, w_j is the weight of product group j and c_{ij} is also the amount of consumed milk with a weight unit of yogurt i of group j.

Milk flow rate constraint

Milk flow rate in a yogurt production line cannot exceed a definite value, and therefore the total yogurt production should not exceed the mentioned rate:

$$\sum_{i=1}^{n_j}\sum_{j=1}^{9} \frac{x_{ijt}\cdot w_j\cdot c_{ij}}{D\cdot PT} \le R \quad for\ t = 1,2,\dots,12 \quad (4)$$

In the above constraint, D equals the number of working days in each month, H is the production hours in a day and R defines milk flow rate in one hour.

Production equipment constraint

Three constraints exist about production equipment: the hot tunnel capacity based on pallet, the cool tunnel capacity based on pallet and the filler constraints. It should be considered that each pallet encompasses a different number of products on the basis of product group weights and it is defined as NP_j. Each pallet should be stayed for several hours in hot and cool tunnel and they are noted as EH and EC, respectively. The number of pallets that can be stayed in the hot and cool tunnel is limited and they are illustrated by NH and NC, respectively. It is mentioned that the available time for hot and cool tunnel is AT hours a day:

$$\sum_{i=1}^{n_j}\sum_{j=1}^{9}\frac{x_{ijt}}{D\cdot NP_j}\le\frac{NC\cdot AT}{EC}\quad for\ t=1,2,\dots,12 \tag{5}$$

$$\sum_{i=1}^{n_j}\sum_{j=1}^{9}\frac{x_{ijt}}{D\cdot NP_j}\le\frac{NH\cdot AT}{EH}\quad for\ t=1,2,\dots,12 \tag{6}$$

In filler constraints, 13 fillers exist for processing milk into products and each of them is utilized for a special range of consumed milk weights and mainly one filler can be used for a different number of products. If k depicts the kth filler, Nf_k is the number of products that the filler k can be filled in an hour. Lf_k and Uf_k are the acceptable lower and upper bounds of filler k for the consumed milk weight. Therefore the set s_{ijk} is defined as follows:

$$s_{ijk}=\{(i,j,k)\,|\,Lf_k\le w_j\cdot c_{ij}\le Uf_k\} \tag{7}$$

And the filler constraint is also defined as follows:

$$\sum_{i,j\in s_{ijk}}\sum\frac{x_{ijt}\cdot w_j\cdot c_{ij}}{D\cdot PT}\le\sum_{k\in s_{ijk}}Nf_k\quad for\ t=1,2,\dots,12 \tag{8}$$

The sale and demand constraints

The different parts of sales organization have the actual ability for selling their products and therefore consider a maximum value for their sales. Some of the strategic products (like diet yogurt) which should be surely sold have a minimum value that is considered zero for other products

$$LS_{ijt}\le x_{ijt}\le US_{ijt}\quad for\ i=1,\dots,j_n\ and\ j=1,2,\dots,9\ and\ t=1,2,\dots,12 \tag{9}$$

LS_{ijt} and US_{ijt} are the minimum and maximum values of product sales in different months, respectively.

On the other hand, the customer demands for all products in each month are forecasted and therefore the whole product production in each month should meet customer demands.

$$\sum_{i=1}^{n_j}\sum_{j=1}^{9}x_{ijt}\ge CD_t\quad for\ t=1,2,\dots,12 \tag{10}$$

In the above formula, CD_t is defined as customer demand in month t.

The top management policy constraint.

Two groups of constraints exist in this area. One is that 500, 900 and 1500 gram full fat yogurts are supplement to each other and the weight sum of each one should be equal to each other. The other is 500 and 900 gram low fat yogurts have the similar condition as the first one:

$$x_{34t}\cdot w_4=x_{26t}\cdot w_6\quad for\ t=1,2,\dots,12 \tag{11}$$

$$x_{34t}\cdot w_4=x_{18t}\cdot w_8\quad for\ t=1,2,\dots,12 \tag{12}$$

$$x_{26t}\cdot w_6=x_{18t}\cdot w_8\quad for\ t=1,2,\dots,12 \tag{13}$$

$$x_{24t}\cdot w_4=x_{16t}\cdot w_6\quad for\ t=1,2,\dots,12 \tag{14}$$

FINDINGS

The required information for solving the proposed model are the profit gained by each yogurt, the amount of consumed milk in each yogurt, the customer demands for all products in each month, the minimum and maximum value of production with consideration of company policies, the yogurt number which is filled by a special filler in an hour, the maximum amount of consumed milk for all and each group of yogurt products, milk flow rate, the number of yogurts which keep in a pallet, the information about the hot tunnel and cool tunnel, the minimum and maximum weight of each filler. These data are gathered from X Company and attached to this paper. The mentioned model is solved by a mathematical solver and the outputs are showed in Table 2. They are also available at the appendix in detail.

Table 2-The optimal solution

CONCLUSION

The production planning of one product family which belongs to the most significant Iranian dairy company is formulated in this paper. Then profit of 12-month production planning which is obtained by this model is compared with those of previous years and it becomes known that the profit of optimal production planning is higher than that of last year which is the outcome of a non-optimal production. This model helps the company to be more efficient and gain much more profit.

The uncertainty of customer demand in different months of the year can be a topic to do research. Furthermore, yoghurt production planning can be extended for all products of X Company in order to obtain a comprehensive production planning which brings high profit with itself.

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