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# Linear programming model for optimum mixing the flour from sieve passages in flour mill industry

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**Abstract**

This study is to design a linear programming model for optimising the mixtures of flour which comes from different sieve passages in flour mill industry. There are different kinds of flour in the market which have different market prices and each has different properties and used for different purposes. The flour obtained from the sieve passages which can be more than 100 in flour milling factories. The characteristics of flour in each sieve passage are different. The main problem is to find out flour mixture plan from sieve passages of the factory in order to maximise the company sales revenue by taking into account the market demand for flour, market prices of flour, sieve passage flour flows and each sieve passage flour properties. In this study, a linear programming model has been developed to support the decision makers for sieve passage flour mixtures optimisation.

Keywords: Linear programming, flour mill ındustry, sieve passage, flour mixture optimisation.

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## 1. Introduction

The flour milling industry has been struggling of dramatic competition in Turkey due to over capacity for a long time. The profitability of the milling companies has been decreasing due to having over a number of milling companies and also new milling companies entering into the market every year (Aktas, 2000). Companies have been spending great effort to find tools to be more competitive in this highly competitive industry. The managers in flour milling companies and researchers on flour milling area mostly focus on optimising the blending wheat in flour milling. Niernberger (1973) was certainly the first to formulate and evaluate a wheat blending model in order to maximise profit from flour milling operations. Generally, we live in a world where blending is performed at wheat level. It should be noted that the most suitable blending for the most efficient and multipurpose milling can be realised with flour blending. There is a lack of studies on flour mixture optimisation for milling industry. This study focuses on optimising the flour mixture from sieve passages in milling industry.

Basically, flour is collected from flour passages in flour milling factories. The number of flour passages depends on the capacity of milling factory. It may be minimum 10 or can be more than 60 passages in a flour mill factory (Ozkaya & Berrin, 2005). The properties and the flow of flour in each flour passages are different. The flour which is supplied to the markets has been produced by selecting and mixing the flour passages. There are different types of flour which have been supplied to markets by flour milling companies. According to Turkish Standard Institute (TSE), flour types are listed based on the percentage of ash amount in the flour. The main problem in flour milling companies is to select the right flour passages to meet standard, and demand from the market while being optimum. Generally, this mixing process has been implemented by supervisor who is mostly withstanding on their past experiences. They make their flour passages mixing plans based on the orders of marketing department of the company without any optimisation sensitivity and any feedback process between planning and marketing department.

It has been recognised that this is a linear programming problem in this study. A linear programming model can be developed with a maximising objective function of sales revenues. This model can be used by production planning managers, decision makers and supervisors to support them to make better decisions and also to support the marketing department to review their marketing policy.

## 2. Materials and methods

One of the basic assumptions of this study is to classify the flour types which are marketed by the milling company based on the TSE standard. Although in the TSE standard the classification is based on the ash content of the flour, in the market, there are also some other parameters such as protein content and diastic activity. The other is the demand of the flour mostly comes for the first three types of flour.

All data have been collected from a milling company which is located in Izmir, Turkey. The capacity of the milling company is 300 tons wheat per day. The number of flour passages in the milling company is 64. According to TSE, the number of flour type and their ash contents has been given in Table 1.

**Table 1. TSE flour standard**

| Flour type | Maximum ash content (%) |
|---|---|
| Type 1 | 0.50 |
| Type 2 | 0.60 |
| Type 3 | 0.65 |
| Type 4 | 0.88 |
| Type 5 | 1.20 |
| Type 6 | 2.00 |

The market prices of those five types of flour are indicated in Table 2. As you recognised, the price of type 6 flour has not given. Type 6 flour has not been included in the model because the company is not selling this type of the flour. As seen in Table 2, type 1 flour is more expensive and is mostly used for high-quality bakery products such as cakes, while types 2 and 3 are used mostly for bread manufacturing.

**Table 2. The market prices of the flour types**

| Flour type (*j*) | Market price (TL/kg) |
|---|---|
| Type 1 | 1.90 |
| Type 2 | 1.86 |
| Type 3 | 1.82 |
| Type 4 | 1.46 |
| Type 5 | 1.30 |

One of the issues in this study was to determine the demand for different types of flour from company markets.

The marketing department has forecasted future demand in terms of the percentage of their total sales for three types of flour and calculated flour demand in terms of kilogram per hour has been shown in Table 3.

**Table 3. Demand for 3 types of flour**

| Flour type | Demand (%) | Demand in kg/h |
|---|---|---|
| Type 1 | $>=$%10 | 479.8 |
| Type 2 | $>=$%60 | 2879.2 |
| Type 3 | $<=$%30 | 1439.6 |

The flour flow and the ash percentages of 64 different flour passages have been shown in Table 4. Those data have been collected and updated periodically by company.

**Table 4. Flour flow rates and ash (%) content of flour passages**

| Passages (*Pi*) | Flour flow(*Ai*) (kg/h) | Ash (%) | Passages (*Pi*) | Flour flow(*Ai*) (kg/h) | Ash (%) |
|---|---|---|---|---|---|
| *P*1 | 98.4 | 0.415 | *P*33 | 49.8 | 0.731 |
| *P*2 | 170.4 | 0.419 | *P*34 | 4.119 | 0.771 |
| *P*3 | 249.6 | 0.421 | *P*35 | 131.4 | 0.772 |
| *P*4 | 342.6 | 0.424 | *P*36 | 27.9 | 0.776 |
| *P*5 | 173.7 | 0.426 | *P*37 | 9.0 | 0.801 |
| *P*6 | 291.0 | 0.442 | *P*38 | 48.89 | 0.817 |
| *P*7 | 88.89 | 0.451 | *P*39 | 41.19 | 0.820 |
| *P*8 | 189.78 | 0.462 | *P*40 | 34.92 | 0.843 |
| *P*9 | 403.2 | 0.477 | *P*41 | 27.18 | 0.859 |
| *P*10 | 92.4 | 0.483 | *P*42 | 109.8 | 0.862 |
| *P*11 | 30.0 | 0.484 | *P*43 | 64.29 | 0.865 |
| *P*12 | 71.4 | 0.486 | *P*44 | 41.49 | 0.879 |
| *P*13 | 16.662 | 0.493 | *P*45 | 6.24 | 0.892 |
| *P*14 | 76.311 | 0.498 | *P*46 | 134.40 | 1.005 |
| *P*15 | 97.8 | 0.557 | *P*47 | 8.49 | 1.010 |
| *P*16 | 85.38 | 0.567 | *P*48 | 40.59 | 1.032 |
| *P*17 | 65.79 | 0.571 | *P*49 | 20.946 | 1.035 |
| *P*18 | 24.06 | 0.577 | *P*50 | 20.13 | 1.071 |
| *P*19 | 95,79 | 0,585 | *P*51 | 1.164 | 1,083 |
| *P*20 | 115.2 | 0.600 | *P*52 | 30.39 | 1.086 |
| *P*21 | 55.89 | 0.613 | *P*53 | 17.511 | 1.096 |

| | | | | | |
|---|---|---|---|---|---|
| *P*22 | 7.93 | 0.632 | *P*54 | 140.4 | 1.140 |
| *P*23 | 40.20 | 0.649 | *P*55 | 64.20 | 1.149 |
| *P*24 | 47.28 | 0.654 | *P*56 | 13.215 | 1.165 |
| *P*25 | 7.722 | 0.656 | *P*57 | 49.29 | 1.223 |
| *P*26 | 45.69 | 0.666 | *P*58 | 39.0 | 1.279 |
| *P*27 | 93.60 | 0.667 | *P*59 | 39.09 | 1.401 |
| *P*28 | 109.20 | 0.673 | *P*60 | 26.82 | 1.423 |
| *P*29 | 85.8 | 0.674 | *P*61 | 15.924 | 1.598 |
| *P*30 | 43.8 | 0.681 | *P*62 | 23.61 | 1.704 |
| P31 | 42.9 | 0.700 | P63 | 16.32 | 1.753 |
| P32 | 31.89 | 0.720 | P64 | 111.6 | 1.760 |

### *2.1.* Linear programming model

#### *2.1.1. Decision variables*

In the model, the decision variables defined as the amount of flour which has been taken from the certain flour passage to produce a certain type of flour. There are 320 variables in the linear programming model. Every flour passage may have been distributed to any of 55 different flour types in any quantity.

Decision variables are denoted by *Xij*, where *i* is the flour passage, and there are 64 flour passages, *j* is the type of flour and there are five types of flour.

#### *2.1.2. Coefficients*

There are two coefficients in the model:

*Market price* is denoted by *Sj*, where *j* is the flour type. There are five different prices for five different flour types which can be seen in Table 2

*Ash percentage of each flour passage* is denoted by *Ai*, where *i* is the passages (Table 4).

#### *2.1.3. Objective function*

The objective function is to maximise the total sales revenue. So that is the sum of the flour quantity from each flour passages to obtain the certain type of flour multiplied by the market price of that type flour, that is

$$Maximize \sum_{i=1}^{m=64} \sum_{j=1}^{n=5} SjXij \qquad (1)$$

#### *2.1.4. Constraints*

*Ash constraints:* Each flour type should have ash content limit in terms of percentage which is shown in Table 1. It is needed to set constraints for five different flour types. Every flour passages may distribute flour to obtain a certain flour type so we need to multiply the ash content of each flour passages with flour quantity of flour passages that goes to obtain certain flour type, and this quantity of total ash should be divided by total quantity of flour which comes from all flour passages to the certain flour type to find the ash percentage of the certain flour type, then this should be limited with ash content limit of ash content of that flour type.

The percentage of ash of flour passage is donated by *Ai* (Table 4). And the ash percentage of each flour type is denoted by *Lj*, which is shown in Table 1. The flow of flour from each flour passage is denoted by *Xij*, which is the decision variable.

The ash constraints for type 1 flour can be written as follows:

$$\sum_{i=1}^{m=64} AiXi1 / \sum_{i=1}^{m=64} Xi1 <= L1 \quad (2)$$

It is required to restructure the ash constraints as follows:

$$\begin{aligned} &\sum_{i=1}^{m=64} (\mathrm{L}1-\mathrm{Ai})*\mathrm{Xi}1>=0 \\ &\sum_{i=1}^{m=64} (\mathrm{L}2-\mathrm{Ai})*\mathrm{Xi}2>=0 \\ &\sum_{i=1}^{m=64} (\mathrm{L}3-\mathrm{Ai})*\mathrm{Xi}3>=0 \\ &\sum_{i=1}^{m=64} (\mathrm{L}4-\mathrm{Ai})*\mathrm{Xi}4>=0 \\ &\sum_{i=1}^{m=64} (\mathrm{L}5-\mathrm{Ai})*\mathrm{Xi}5>=0 \end{aligned} \quad (3)$$

*Demand constraints*: This is simply the total of flour quantity that comes from each flour passage should not be less than the demand for certain flour type, that is

$$\begin{aligned} &\sum_{i=1}^{m=64} \mathrm{Xi}1<=479{,}8 \\ &\sum_{i=1}^{m=64} Xi2<=2879{,}2 \\ &\sum_{i=1}^{n} Xi3<=1432.6 \end{aligned} \quad (4)$$

*Quantity constraints:* It is needed to put 64 constraints into the model for each flour passages. The passage flour flow is denoted by *Pi*. All passages have a certain amount of flour flow per hour, so the quantity of flour which has been distributed from one flour passage to five different flour types cannot exceed the flour flow of that passage per hour, that is

$$\sum_{j=1}^{n=5} X1j <= P1 \quad (5)$$

$$\sum_{j=1}^{n=5} X64j <= P64 \quad (6)$$

*Non-negativity constraints:*

$$Xij >= 0$$

The model has been solved by using QSB software based on the simplex algorithms. The optimum solution has been obtained by 322 iterations. The result of the sensitivity analyses has also been obtained.

## 3. Results and discussions

The result of the solution of linear programming model has been shown in Table 5. As it can be seen in the table, all the passages have been distributed to the four different flour types. And the demand from the market has been met. According to the solution result, there is no production of type 4 flour. The objective function that shows the sales revenue per hour has calculated as 8.581.869 TL by model solution.

Flour from some of the flour passages has been distributed to more than one flour type. In most of the milling factories, the production facilities cannot allow to split flour flow of one flour passage. The integer linear programming can be used to avoid this problem.

Although the greatest affect to the value of objective function comes from the type 3 flour, the quantity of type 3 flour in production plan is less. The reason for that is the necessity of meeting the demand for type 2 flour and type 1 flour in the model. The managers can decide to investigate the result of reducing the market price of type 3 flour and increase the demand of the type 3 flour. As it is mentioned before, the model can help managers who make the decisions and policies of the company.

**Table 5. The results from model solution**

| Flour passages | Total flour flow of passages (kg/h) | Quantity of flour comes from passage for type 1 flour(kg/h) | Quantity of flour comes from passage for type 2 flour (kg/h) | Quantity of flour comes from passage for type 3 flour (kg/h) | Quantity of flour comes from passage for type 4 flour (kg/h) | Quantity of flour comes from passage for type 5 flour (kg/h) |
|---|---|---|---|---|---|---|
| *P*1 | 98.4 | 98.4 | 0 | 0 | 0 | 0 |
| *P*2 | 170.4 | 170.4 | 0 | 0 | 0 | 0 |
| *P*3 | 249.6 | 31.629 | 217.967 | 0 | 0 | 0 |
| *P*4 | 342.6 | 0 | 342.60 | 0 | 0 | 0 |
| *P*5 | 173.7 | 0 | 0 | 173.70 | 0 | 0 |
| *P*6 | 291.0 | 0 | 291.00 | 0 | 0 | 0 |
| *P*7 | 88.89 | 0 | 88.89 | 0 | 0 | 0 |
| *P*8 | 189.78 | 0 | 0 | 189.78 | 0 | 0 |
| *P*9 | 403.2 | 0 | 403.20 | 0 | 0 | 0 |
| *P*10 | 92.4 | 0 | 924.00 | 0 | 0 | 0 |
| *P*11 | 30.0 | 0 | 30.00 | 0 | 0 | 0 |
| *P*12 | 71.4 | 0 | 71.40 | 0 | 0 | 0 |
| *P*13 | 16.662 | 0 | 0 | 16.662 | 0 | 0 |
| *P*14 | 76.311 | 0 | 76.311 | 0 | 0 | 0 |
| *P*15 | 97.8 | 0 | 97.80 | 0 | 0 | 0 |
| *P*16 | 85.38 | 0 | 85.38 | 0 | 0 | 0 |
| *P*17 | 65.79 | 65.79 | 0 | 0 | 0 | 0 |
| *P*18 | 24.06 | 0 | 24.06 | 0 | 0 | 0 |
| *P*19 | 95.79 | 95.79 | 0 | 0 | 0 | 0 |
| *P*20 | 115.2 | 0 | 115.20 | 0 | 0 | 0 |
| *P*21 | 55.89 | 0 | 55.89 | 0 | 0 | 0 |
| *P*22 | 7.93 | 0 | 7.93 | 0 | 0 | 0 |
| *P*23 | 40.20 | 0 | 40.20 | 0 | 0 | 0 |
| *P*24 | 47.28 | 0 | 19.828 | 27.451 | 0 | 0 |
| *P*25 | 7.722 | 0 | 7.722 | 0 | 0 | 0 |
| *P*26 | 45.69 | 0 | 45.69 | 0 | 0 | 0 |
| *P*27 | 93.60 | 0 | 93.6 | 0 | 0 | 0 |
| *P*28 | 109.20 | 0 | 0 | 109.02 | 0 | 0 |
| *P*29 | 85.8 | 0 | 85.80 | 0 | 0 | 0 |
| *P*30 | 43.8 | 0 | 43.80 | 0 | 0 | 0 |
| *P*31 | 42.9 | 0 | 42.09 | 0 | 0 | 0 |
| *P*32 | 31.89 | 0 | 0 | 31.89 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *P*33 | 49.8 | 0 | 0 | 49.80 | 0 | 0 |
| *P*34 | 4.119 | 0 | 4.119 | 0 | 0 | 0 |
| *P*35 | 131.4 | 0 | 85.158 | 46.241 | 0 | 0 |
| *P*36 | 27.9 | 0 | 27.9 | 0 | 0 | 0 |
| *P*37 | 9.0 | 0 | 0 | 9.00 | 0 | 0 |
| *P*38 | 48.89 | 0 | 0 | 48.99 | 0 | 0 |
| *P*39 | 41.19 | 0 | 41.19 | 0 | 0 | 0 |
| *P*40 | 34.92 | 0 | 34.92 | 0 | 0 | 0 |
| *P*41 | 27.18 | 0 | 27.18 | 0 | 0 | 0 |
| *P*42 | 109.8 | 0 | 0 | 109.80 | 0 | 0 |
| *P*43 | 64.29 | 0 | 64.29 | 0 | 0 | 0 |
| *P*44 | 41.49 | 0 | 0 | 0 | 0 | 41.49 |
| *P*45 | 6.24 | 0 | 6.24 | 0 | 0 | 0 |
| *P*46 | 134.40 | 0 | 78.29 | 0 | 0 | 56.37 |
| *P*47 | 8.49 | 0 | 0 | 0 | 0 | 8.49 |
| *P*48 | 40.59 | 0 | 40.59 | 0 | 0 | 0 |
| *P*49 | 20.946 | 0 | 0 | 0 | 0 | 20.946 |
| *P*50 | 20.13 | 0 | 0 | 0 | 0 | 20.13 |
| *P*51 | 1.164 | 0 | 0 | 1.164 | 0 | 0 |
| *P*52 | 30.39 | 0 | 0 | 0 | 0 | 30.39 |
| *P*53 | 17.511 | 0 | 0 | 0 | 0 | 17.511 |
| *P*54 | 140.4 | 0 | 0 | 0 | 0 | 140.40 |
| *P*55 | 64.20 | 0 | 0 | 0 | 0 | 64.20 |
| *P*56 | 13.215 | 13.215 | 0 | 0 | 0 | 0 |
| *P*57 | 49.29 | 4.572 | 0 | 0 | 0 | 44.717 |
| *P*58 | 39.0 | 0 | 0 | 0 | 0 | 39.00 |
| *P*59 | 39.09 | 0 | 0 | 0 | 0 | 0 |
| *P*60 | 26.82 | 0 | 0 | 0 | 0 | 26.82 |
| *P*61 | 15.924 | 0 | 0 | 0 | 0 | 15.924 |
| *P*62 | 23.61 | 0 | 0 | 0 | 0 | 23.61 |
| *P*63 | 16.32 | 0 | 0 | 0 | 0 | 16.32 |
| *P*64 | 111.6 | 0 | 90.824 | 0 | 0 | 20.775 |
| TOTAL | 4798.6842 | 479.796 | 2879.198 | 852.588 | 0 | 587.0939 |

## 4. Conclusion

Linear programming seems to be a very effective way to transform data into valuable information to support the daily decision making regarding production planning by mixing the flour from passages. In this research, a linear programming model has been applied to the determination of optimal production plan for five different flour type production by maximizing sales revenue .The model was developed in a way that it can be implemented on any kind of flour milling company, only by applying different data to the model. The model was designed to be used as a decision tool for the flour milling factories.

Although the managers of the company where the model has been applied were satisfied with the results of the model solution, a further study on more milling companies should be done to compere flour passage mixture plans which have been made by using the model results and existing flour passage mixture plans which have been made using supervisor’s experiences. There are certain relation between the properties of wheat which is used to have flour and the properties of flour from passages in milling factory. A further research should be focused on integrating an optimisation both wheat and flour from passages in milling factories.

## References

Erkan, A. & Oguz, Y. (2000, Eylul 6–8). *Turkiyede Un Sanayinin Yapisi*. Ulasal Tarim Ekonomisi Kongresi, Tekirdag, Turkey.

Hayta, M. & Cakmakli, U. (2001). Optimization of wheat blending to produce breadmaking flour. *Journal of Food Process Engineering, 24*, 179–192.

Niernberger, F. F. (1973). Blending wheat to meet product specifications. *Bulletin-Association of Operative Millers*, 3395–3400.

Ozkaya, H. & Berrin, O. (2005). *Ogutme Teknolojisi*. Ankara, Turkey: Ankara Universitesi.

TSE. (1985). *TS 4500 Un standardi*. Ankara, Turkey: Turk Standartlari Enstitusu.