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Research Article

Evaluating the Performance of the Production Line with Simulation Approach in Meat Processing Industry: A Case from Turkey

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ABSTRACT

The production capacity and employment in the meat processing industry in Turkey has increased in parallel with the demand of the growing population. The meat processing industry turns animal raw materials into ready-to-eat products with a long shelf life such as sausages, garlic-flavored fermented sausages, salami, bacon, roasted meat, and ham. It is clear that the meat processing industry is entirely dependent on animal husbandry. However, due to animal production rate exceeds the rate of meat consumption in Turkey, both government agencies and organizations, as well as meat processing companies, are forced to manage the demand for meat and to improve their production lines. In this study, in order to meet the increasing demand of customers in a meat processing company operating in Istanbul, 4 different scenarios were developed with the idea of how to create more final products in the same working time. The scenarios were examined using the simulation model and the utilization rates of machines have been evaluated. In addition, the effects of the scenarios on the final product amount were discussed. Thus, the findings of the study assisted the decision-makers in the company for the selection of the right approach.

Keywords: Simulation, Meat Production, Meat Processing Industry, Food Processing, Productivity, ARENA Software

1. Introduction

For consumers, the tendency towards issues that increase their quality of life and affect their welfare and health levels is increasing day by day. As the reasons for this increase; it is possible to show the increasing life expectancy of the population, more concerns about the prevention of diseases and the sharing of the media and the public. Healthy eating, including healthy and balanced foods, is not the only issue to be considered in this regard, but it is one of the most important. Numerous scientific evidence emphasizing the link between adequate food intake and frequency of disease has led to an increment interest in healthy foods (Jiménez-Colmenero et al. 2001).

Red meat is of great importance for healthy eating. Although high red meat consumption in many countries has been criticized for contributing to the emergence of chronic diseases such as hypertension, obesity, cardiovascular disease, diabetes and some cancers (Jiménez-Colmenero et al. 2001; De Smet and Vossen 2016; Walker et al. 2005), the adequate consumption of red meat ensures that the immune system performs its normal function, especially during the periods of more need, such as illness, pregnancy. It is a serious source of protein, rich in vitamin B12, containing essential nutrients such as iron and zinc (McAfee et al. 2010). In addition, it contains compounds like fat, fatty acids, sodium etc. (Jiménez-Colmenero et al. 2001). Therefore, the adequate consumption of meat is particularly recommended for elders and growing children (Biesalski 2005).

Turkey's diversity in terms of climate and geographical structure, affects the diversity of animal husbandry activities. While there is dairy farming in Turkey's west, south and inland regions; the eastern provinces are especially Turkey's livestock supply center (Demirkol and Azabagaoglu 2017).

In parallel with the rapid growth of Turkey's population, meat consumption has risen over the years and this has increased the production capacity and employment of the meat processing industry. While 88% of the red meat production is from cattle in Turkey, the remaining part is obtained from ovine (Akgül and Yildiz 2016; Karakuş et al. 2018). According to the data of Turkısh Statistical Institute (TSI)[1], production amount of various meat products from 2010 to 2017 are pointed out in Table 1. According to these amounts, total red meat production in 2017 increased by 44.3% compared to the total red meat production in 2010.

Year/Group	2010	2011	2012	2013	2014	2015	2016	2017
Goat Meat, Fresh or Cooled	23,061	23,318	17,430	23,554	26,770	33,990	31,011	37,525
Sheep Meat, Fresh or Cooled	135,688	107,076	97,334	102,943	98,977	100,021	82,485	100,058
Buffalo Carcasses, Half or Quarter Bone Carcasses, Fresh or Cooled	3,387	1,615	1,736	336	525	326	351	1,339
Cattle or Calf Carcasses, Half or Quarter Bone Carcasses, Fresh or Cooled	618,583	644,906	799,344	869,292	882,000	1,014,925	1,059,196	987,481
TOTAL	780,719	776,915	915,844	996,125	1,008,272	1,149,262	1,173,043	1,126,403

Table 1. Red meat production in Turkey according to animal species (tonnes) (2010-2017)

[1] https://biruni.tuik.gov.tr/medas/?kn=79&locale=tr

Numerous animal breeding and processing industry systems were first used in the poultry industry in the 1930s and 1940s. Subsequently, the cattle, goat, sheep, pig industries adopted industrial procedures [3]. The meat processing industry converts animal raw material into a product that has a long shelf life and is ready for consumption. Sausage, fermented sausage with garlic flavour, salami, bacon, roasted meat, ham are the leading products of this industry (Polat and Cevger 2016). Many institutions and organizations are involved in delivering the products produced in the red meat processing industry to consumers in Turkey. These include;

- Municipal slaughterhouses and combined facilities
- Combined facilities of Meat and Fish Institution
- Private sector slaughterhouses and combined facilities
- Private sector facilities that produce meat products (Saygın and Demirbaş 2017)

Aydogdu and Kucuk (2018) calculated Turkey's red meat consumption values for 2023 with trend analysis based on the TSI's data between 2010-2017. According to the results, red meat consumption per capita will be 39.5% higher in 2023 than in 2017. On the other hand, the number of animals expected to be in 2023 will increase by 2% compared to 2017. This expected insufficient rise in the number of animals is mainly due to the migration of the young population in rural areas to cities, the high cost of livestock input and the inability to provide adequate support to animal husbandry by the state. Therefore, the problem of meeting the demand for red meat manifests itself as a problem that should be dealt with by both state institutions and private meat processing companies.

This study was carried out on the delicatessen production line of a company that has a significant market share in the meat processing industry. In order to meet the increasing demand of the company operating in Istanbul, 4 different scenarios were developed with the idea of how to create more final products at the same working time. The results of the developed scenarios were analyzed using the simulation model created on Rockwell ARENA software. As a result of the analysis, the increased capacity utilization rates of the machines in the production line were evaluated. In addition, the effects of changes in the company's production plan of the company on the final product were discussed.

The general flow of the study is as follows: A detailed literature review for simulation applications in the food industry is presented in the second section. In the third section, the content and the details of the case are given. The fourth section summarizes the results and finally, the fifth section concludes the study.

2. Literature Review

In this section, the studies in the literature, which include simulation applications in the food sector, are presented.

Abed (2008), increased the speed of the Rusk production line to meet the increasing demand for the product within the existing limited space. In this study, a simulation experiment consisting of 7 different scenarios was conducted. Machines were added to the production line and existing machines were changed. In addition, the duration

of the process without the impact on the quality of the product reduced. As a result, bottlenecks were eliminated and waiting times in production were improved. This resulted in an increase of 50% in production and a decrease of 11.4% in total production time. It is foreseen that the investment to be made on the production line will return to the firm as profit within 35 days.

Hussein et al. (2009) modelled 10 different types of products in a small bakery production line using the ARENA simulation program. The efficiency of the production plans was calculated based on real data and bottlenecks were determined. In this study, various performance criteria such as waiting time on the production line, utilization rate of the devices (idle or busy) and working time of the personnel were also examined.

Hecker et al. (2010) analysed the production process of a bakery in Germany. They examined the use of models that acted as real systems instead of experience-based production plans. The goal was to model the production line and achieve an efficient process simulation. First of all, the simulation data was verified and the used production plan found as not optimal. Then the production plan was changed and the effects of this change on the results were examined. As a result, a new production plan was created with lower total working time and a higher machine utilization rate.

Bruzzone and Longo (2013) aimed to support decision making in a production system by developing a java-based simulation tool in the study which is carried out in the hazelnut industry. The developed tool has flexibility in defining different scenarios. Thus, a decision maker will be able to use this tool as a decision support system to understand the dynamic interactions among a number of users and between multiple performance metrics.

Parthanadee and Buddhakulsomsiri (2014) worked on a coffee company with a capacity limitation. In this study, value stream mapping (VSM) and simulation approaches were used together. Areas that need to be focused for improvement were identified with VSM. On the other hand, the system simulation approach examined the effect of the proposed models on the process without changing the existing system.

Rani et al. (2014a) conducted a simulation study in an SME producing cassava-based food in Malaysia. They made changes in the working principles of existing production personnel and examined five different models. They used the Data Envelopment Analysis (DEA) model to find out which model was more effective. In another study Rani et al. (2014b) used Analytical Hierarchy Process (AHP) and computer simulation together. They determined the performances of 17 operators by AHP method under 7 main criteria. Then, operators were grouped according to the calculated performances, each group was assigned to a certain process and the effect of this assignment on production line was evaluated by computer simulation.

Armenzoni et al. (2016) studied the milking process of a farm that provides milk for the production of Parmigiano Reggiano, which is Italian hard cheese. The study aimed to facilitate the management of farm processes by reducing milking times. The milking process was observed as a variable depending on animal behaviour and it was thought that decreasing this time would increase productivity. From this point of view, firstly the current situation was designed with the simulation program SIMUL8

and it was examined whether the current milking process provided the 4-hour time limit. The characteristics of the animals, farm layout and milking operations were analysed and the data required for the model were collected. Then the accuracy of the model was checked. In the second part of the study, two scenarios were created and the decrease in milking times was evaluated.

Liong et al. (2016) conducted a simulation study on a pepper sauce production line of an SME operating in Malaysia. The reason why system simulation is preferred in this study was that simulation could be applied without changing the usual flow and costs low. As a first step, the processes were analysed and data were collected. Then the model was established and the inter-component structure was formulated. After the model was completed, the verification process was performed. Average processing time, average waiting time, total preparation time and resource utilization rates were used as performance criteria. As a result of the simulation of the existing system, bottlenecks are determined and resource utilization rates were found as not sufficient. In order to create a more efficient system, 4 different models were proposed. By comparing the performance criteria, the model producing more products and having higher resource utilization was determined.

Wang et al. (2018) modelled a single wheat flour production line in Flexsim simulation software and examined the utilization rates of the machines in the line. They then ran a proposed model, which include some improvements on the existing line. In the proposed model, wheat flour production increased from 10,645 to 21,290 and the utilization rates of the machines on the line were greatly improved.

Hasan et al. (2019) analyzed the yogurt production line in Abu Ghraib Dairy Factory using Arena simulation software. They focused on the waiting times and machines' efficiency for each process. According to the simulation results, the machine utilization rates being less than 80% guarantee the system running completely over a long production period. Moreover, this rates allow improvements to be made to increase the system's responsiveness to demand.

The study of Kamarudin et al. (2019) consists of two parts. In the first part, they examined the CHOKEE product production line with simulation. The production line was divided into four processes, premix, mix, filling and packaging, and the first aim of the study was to identify bottlenecks on these processes. As a result of the simulation, the average waiting time, the average processing time and the average total processing time were considered and the areas that could be improved were identified. In the second part, they suggested 14 improvement models and based on these models, best alternative was determined with data envelopment analysis (DEA). While the inputs of the DEA model were the number of workers, the average total production time and the average number of entities in the system, the average worker utilization and the average total production were taken as outputs.

3. Background of the Company

The content of this study is the delicatessen production line of the integrated meat and meat products facility, which has been carrying out its production activities in Istanbul-Tuzla since 1984. The company is among the Turkey's top 500 companies and produces processed and unprocessed products such as fresh meat, frozen meat,

delicatessen (include sausage, fermented sausage with garlic flavour, salami, bacon, roasted meat, ham), doner kebab and hamburger patties. The delicatessen group has the highest product range and is the most complex production line. The expanding product range due to the company's R & D activities led to an increasing trend in sales volume. As a result of these demand fluctuations, workloads of work centers increased and unequal workload distribution, one of the biggest problems of the company, emerged. The capacity of the transport unit that is used for transporting the products between the work centers was another problem of the company. These problems also disrupted the weekly production plan. Productivity has decreased due to the increasing unbalanced workload in the packaging work center. Therefore, the company requested to perform a study using the data of this production line.

The company expects from this study to maximize the machine utilization rates and production and packaging quantities realized in a certain period of time, while discussing different scenarios, which take into account new demands. In addition, if the final product quantity increases, the company's order fulfillment rates will automatically rise. On the other side, ensuring that products are packed faster during the packaging step will make the transport units used between the work centers reusable.

3.1. Production Analysis of the Delicatessen Production Unit

The first step of production in the delicatessen unit starts with the coming of the raw materials to the facility in compliance with the cold chain. The raw materials tested by suppliers are subjected to a second test at the facility. Then, approved raw materials are either transferred directly to the production unit according to the daily need or directed to the stock area.

The processing of the raw material transferred to the delicatessen production unit is carried out according to the work orders that are opened according to the days and number of lots included in the weekly production plan. Lot sizes are different for each product group. The raw materials defined according to work orders are first passed through meat grinders. Then they are then taken into the mixing chamber and mixed with spices. After this process, each product group undergoes its own filling step.

Following the filling step, fermentation process is applied for the sausage with garlic flavour group products. After fermentation, the products are baked, dried and packaged after drying. The sausage group products are directly baked. The sausages that come out of the oven are taken into cooling tanks and can be packaged when their temperature drops. For salami group products, the same procedures are applied as sausage group products. If the product is block salami type, it is packaged after cooling. If the product is sliced salami, it is kept in the shock tank for an average of 3 hours. Products that complete the waiting period in shock storage can be packaged.

The transportation of the product groups to the packaging work center is carried out by the transportation units. Transportation units are located in this work center until the packaging process is finished, and after being emptied, they are delivered to the baking process. Thus, they are used to for transporting the products again.

The process flow in delicatessen production unit is shown in Figure 1.

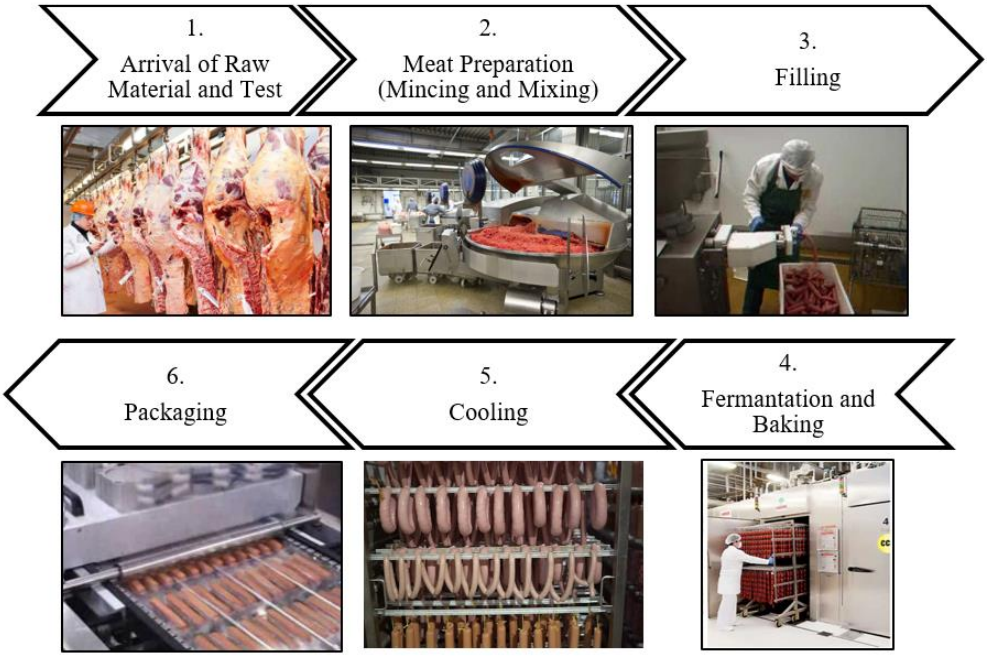

Figure 1. The process flow in delicatessen production unit

As mentioned above, raw materials are processed according to the weekly production plan. The production plan is prepared following the communiqué issued by the Turkish Food Codex (Communiqué On Turkish Food Codex Meat And Meat Products, Date: 29 January 2019, No:30670 Article 5/1c)[2]. According to this communiqué, the meat of different animal species (calf, chicken, turkey) should be produced separately from each other and other foods. When product groups in different animal species are included in the production on the same day, washing is required in the machines. Therefore, in order to minimize the washing time in the discussed delicatessen production unit, it is desirable to produce each different animal species on different days as much as possible. Therefore, the current weekly production plans are made considering the following items:

- Products should be included in production in order to maximize the order fulfillment rate.
- Product groups in same animal species (like chicken and turkey) should be brought into production on the same day to minimize the washing procedure.

Table 2 shows an example of the weekly production plan currently used by the company in the delicatessen production unit in line with these items.

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Sausage with garlic flavour products	Calf group	Calf group	Chicken group	Calf group	
Sausage products	Calf group	Turkey group	Chicken group	Calf group	Calf group
				Chicken group	
Salami products	Calf group	Turkey group	Chicken group	Calf group	Calf group
			Turkey group		

Table 2. Product group distribution of the current weekly production plan of the delicatessen production unit

[2] http://www.resmigazete.gov.tr/eskiler/2019/01/20190129-4.htm

4. Application and Results

In order to improve the current situation of the company, 4 scenarios were developed taking into account the demands and the existing constraints of the company, and the results were evaluated. This section includes these scenarios and their results.

4.1. Scenario 1: Recommended Production Plan For Delicatessen Production Unit

The quantities required to be produced according to the weekly production plan cannot be produced on time in the delicatessen production unit. Especially in sausage and salami group products, the demand fulfillment is not provided. Therefore, the utilization rates and unbalanced workload distributions of the sources causing the bottleneck should be improved. For this reason, it is decided to revise the weekly production plan.

The modified weekly production plan has been prepared by taking into account the following items:

- Products should be included in production in order to maximize the order fulfillment rate.
- Instead of producing the product groups in same animal species (like chicken and turkey) on the same day, all lines should operate at maximum.
- The waiting times of transportation units and semi-finished products should be minimized.

The restructured weekly production plan for the company's delicatessen production unit is given in Table 3.

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Sausage with garlic flavour products	Calf group	Calf group	Chicken group	Calf group	
Sausage products	Calf group	Calf group	Calf group	Calf group	Calf group
	Turkey group	Chicken group	Chicken group		Chicken group
			Turkey group		
Salami products	Calf group	Calf group	Calf group	Calf group	Calf group
	Turkey group	Turkey group	Chicken group		Turkey group
			Turkey group		

Table 3. Product group distribution of the proposed weekly production plan of the delicatessen production unit

When the difference between the proposed production plan and the current production plan is examined, it is clearly seen that the production of different types of animals is included on the same day in order to meet the demand, especially sausage and salami group products. Although this seems to be a disadvantage due to the washing process, it is predicted that it will increase the output amount.

In order to determine the effectiveness of the proposed weekly production plan, the company's delicatessen production process was first modelled through the Rockwell ARENA 14.0 simulation software. The screenshot of the model is presented in Figure 2.

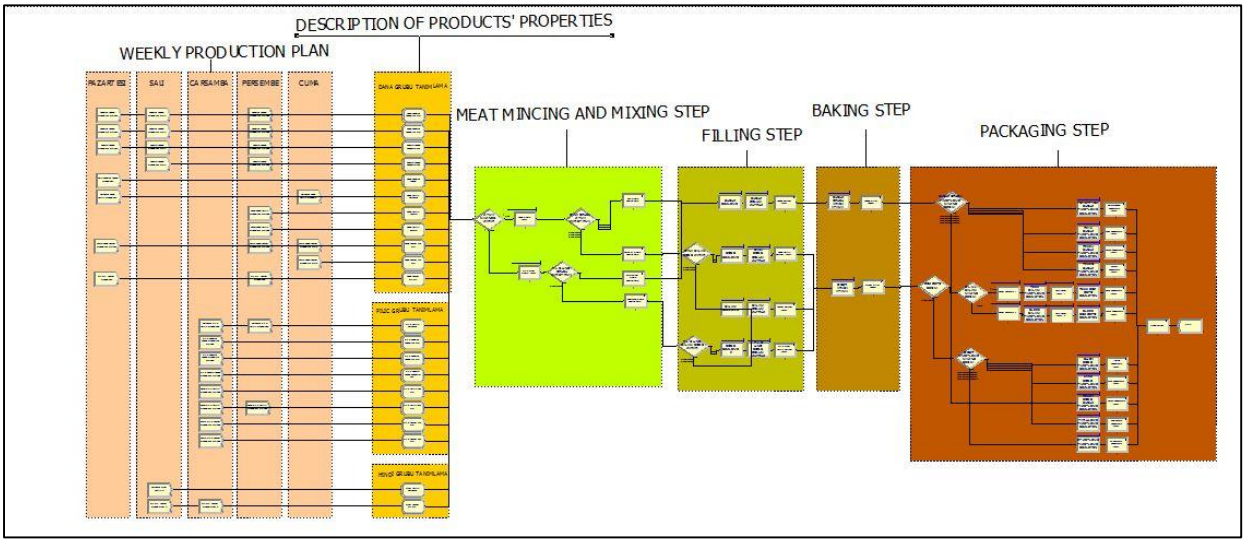

Figure 2. The screenshot of the model created for the delicatessen production unit

The assumptions made during the execution of the model are as follows:

- There is a sufficient number of personnel in the work units.
- minute/kg is taken as basis for the determination of productivity in the filling, baking and packaging steps.

The current situation and the proposed production plan were run on the ARENA model. Table 4 shows the number of machine washings in both cases during the delicatessen production process.

	The Number of Machine Washings	
	Current Weekly Production Plan	Proposed Weekly Production Plan
Meat Preparation Step	3	6
Filling Step	19	34
Packaging Step	11	40

Table 4. The number of machine washings for the current weekly production plan and the proposed weekly production plan

In the proposed new production plan, it was observed that the number of machine washings is higher. This was because this model examines the production of two or more product groups during the one-day. However, in the proposed production plan, there are fewer lots where the filling process cannot be performed compared to the current situation. Table 5 shows the number of lots that cannot be filled for the current and proposed production plans.

	Current Weekly Production Plan	**Proposed Weekly Production Plan**
Number of lots waiting to be mixed	8	1
Number of parties waiting for filling	4	6
Total	12	7

Table 5. The number of lots that cannot be filled for the current weekly production plan and the proposed weekly production plan

It is planned to produce the same amount of product (226,583.5 kg) in both the current and the proposed models. However, both models failed to complete the weekly production plan. Table 6 shows the production amounts of the current and the proposed production plans. Accordingly, the current production plan completes

87% of the weekly production plan, while the proposed production plan completes 93% of the weekly production plan. As can be seen from Table 6, the proposed production plan filled 6.6% (12,960 kg) more product than the current production plan. Furthermore, the proposed production plan delivered 2.9% (5,400 kg) more products to the next steps for packaging. It is another output that 32% more products were packaged in the proposed production plan than the current situation.

	Current Weekly Production Plan	Proposed Weekly Production Plan	Change rate (%)
Production plan amounts (kg)	226,583.5	226,583.5	0
Filling amounts (kg)	197,422.5	210,382.5	6.6
Amount of products that can be packed (kg)	185,287.5	190,687.5	2.9
Amount of products packed (kg)	77,583.04	102,425.3	32

Table 1. Production amounts for the current weekly production plan and the proposed weekly production plan

Table 7 shows the distribution of packaged products by product group. The proposed production plan showed an increase in the packaging of the chicken group products according to the current production plan.

	Current Weekly Production Plan	Proposed Weekly Production Plan	Change rate (%)
Calf group products (kg)	37,995	47,798	25.8
Chicken group products (kg)	23,742.40	35,917.86	51.2
Turkey group products (kg)	15,800.64	18,709.44	18.4
Total	77,538.04	102,425.30	32

Table 7. Product group-based amounts of packaged products for the current weekly production plan and proposed weekly production plan

4.2. Scenario 2: Changing Delicatessen Production Plan and Adding Printer

It is clear that the unbalanced workload existing in the delicatessen production unit is made more balanced with the proposed production plan in Scenario 1 and the amount of final product is increased. However, in addition to changing the production plan, it may be possible to further increase the amount of products by improving the physical possibilities. For physical improvement, it is important for the organization to balance the earnings from change with the cost of change.

In Scenario 2, a new assessment has been made, taking into account the proposed production plan in Scenario 1, and adding a printer to the packaging step will increase the flow at that step. The printer is a common tool between machines and allows information such as weight and expiry date to be overwritten on the packaged product. It is among the most cost-effective tools in packaging machines. Table 8 shows the amount of product obtained according to scenario 2 and their variation according to the current situation.

	Current Weekly Production Plan	Adding Printer to the Proposed Weekly Production Plan	Change rate (%)
Production plan amounts (kg)	226,583.5	226,583.5	0
Filling amounts (kg)	197,422.5	212,002.5	7.4
Amount of products that can be packed (kg)	185,287.5	191,227.5	3.2
Amount of products packed (kg)	77,583.04	103,615.1	33.6

Table 8. Production amounts for the current weekly production plan and when a printer added to the proposed weekly production plan

Table 9 shows the distribution of the packaged products by product group according to the current situation and scenario 3.

	Current Weekly Production Plan	Adding Printer to the Proposed Weekly Production Plan	Change rate (%)
Calf group products (kg)	37,995	47,798	25.8
Chicken group products (kg)	23,742.40	37,107.66	56.3
Turkey group products (kg)	15,800.64	18,709.44	18.4
Total	77,538.04	103,615.10	33.6

Table 9. Product group-based amounts of packaged products for the current weekly production plan and when a printer added to the proposed weekly production plan

4.3. Scenario 3: Changing Delicatessen Production Plan and Increasing Freezer Speed For Sliced Salami Group

In this scenario, in addition to the all the changes made in Scenario 1, an improvement was achieved in the process. In the sliced salami group, the products must be frozen before cutting. Thus, more uniformly slices can be obtained. However, the long process time of the freezer affects the output amount. Therefore, it was aimed to investigate how a faster freezer will affect the output amount.

According to the mentioned improvement, it was found that during the delicatessen production process, when production was made according to the production plan proposed in Scenario 1 and the freezer speed was increased for the cutting process before the packaging stage, 6.6% (12,960 kg) more product was filled than the current situation. The amount of packaged product has increased by 56.3% (43,667.02 kg) compared to the current situation.

While Table 10 shows the distribution by product groups according to the current situation and scenario 4, Table 11 presents the distribution of the packaged products by product group according to the current situation and scenario 3.

	Current Weekly Production Plan	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan	Change rate (%)
Production plan amounts (kg)	226,583.5	226,583.5	0
Filling amounts (kg)	197,422.5	210,382.5	6.6
Amount of products that can be packed (kg)	185,287.5	190,687.5	2.9
Amount of products packed (kg)	77,583.04	121,250.06	56.3

Table 10. Production amounts for the current weekly production plan and when the freezer speed for sliced salami group was increased in the proposed weekly production plan

	Current Weekly Production Plan	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan	Change rate (%)
Calf group products (kg)	37,995	50,129	31,9
Chicken group products (kg)	23,742.40	35,917.86	51.2
Turkey group products (kg)	15,800.64	35,203.2	122.8
Total	77,538.04	121,250.06	56.3

Table 11. Product group-based amounts of packaged products for the current weekly production plan and when the freezer speed for sliced salami group was increased in the proposed weekly production plan

4.4. Scenario 4: Changing Delicatessen Production Plan, Increasing Freezer Speed For Sliced Salami Group and Adding Printer

Although there is a cost incurred by companies with new machine purchases, this investment cost can be covered in a short time with the increasing amount of output. Therefore, in scenario 4, which is the combination of scenario 2 and scenario 3, it was assumed that the production plan was changed, the speed of the freezer used for the sliced salami group was increased, and a printer was added to the packaging process.

As a result of the analyzes made in line with these assumptions, it was determined that 6.6% (12,960 kg) more product filling has been made according to the current situation. The amount of packaged products increased by 57.9% (44,856.84 kg) compared to the current situation. Table 12 shows the amount of changes obtained in line with scenario 4.

	Current Weekly Production Plan	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan and Adding Printer	Change rate (%)
Production plan amounts (kg)	226,583.5	226,583.5	0
Filling amounts (kg)	197,422.5	210,382.5	6.6
Amount of products that can be packed (kg)	185,287.5	190,687.5	2.9
Amount of products packed (kg)	77,583.04	122,439.88	57.9

Table 12. Production amounts for the current weekly production plan and when the freezer speed for sliced salami group was increased and a printer added in the proposed weekly production plan

Table 13 shows the distribution of the packaged products by product group according to the current situation and scenario 4.

	Current Weekly Production Plan	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan and Adding Printer	Change rate (%)
Calf group products (kg)	37,995	50,129	31,9
Chicken group products (kg)	23,742.40	37,107.66	56.3
Turkey group products (kg)	15,800.64	35,203.22	122.8
Total	77,538.04	122,439.88	57.9

Table 13. Product group-based amounts of packaged products for the current weekly production plan and when the freezer speed for sliced salami group was increased and a printer added in the proposed weekly production plan

5. Conclusion

As in every sector, increasing demand in the meat processing industry needs to be managed effectively. In this study, the problems due to the increasing demand in the delicatessen production unit of a company operating in the meat processing industry in Turkey were handled with a simulation study. Within the scope of the study, 4

different scenarios were developed and the current capacity utilization rates of the machines in the production unit were evaluated. Also, how to create more final products in the same working period was evaluated with the proposed scenarios.

While the problems in the company where the study was carried out are explained in section 3, it was stated that the current production plan in the delicatessen production unit causes an unbalanced workload distribution and this affects the usage rates of the machines in the packaging process. Table 14 shows the usage rates of packaging machines in the current production plan and with different scenarios.

Machine Name	Current Weekly Production Plan	Proposed Weekly Production Plan (Scenario 1)	Adding Printer to the Proposed Weekly Production Plan (Scenario 2)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan (Scenario 3)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan and Adding Printer (Scenario 4)
5200	6.0 %	26.7 %	26.7 %	26.7 %	26.7 %
Labelling	0.2 %	0.6 %	5.7 %	0.5 %	0.6 %
Inkjet	29.5 %	28.7 %	29.2 %	28.6 %	29.1 %
Inkjet 2	-	-	0.6 %	-	0.6 %
Ishıda	36.5 %	49.7 %	49.7 %	49.7 %	49.7 %
Powerpack	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %
R230G	10.3 %	10.3 %	10.3 %	10.3 %	10.3 %
R230V	8.9 %	8.6 %	9.3 %	8.9 %	9.3 %
R230Y	4.7 %	4.6 %	4.7 %	4.7 %	4.7 %
R245	5.4 %	4.6 %	4.9 %	4.7 %	4.9 %
R353	43.8 %	43.8 %	43.8 %	47.7 %	47.7 %
SI800	9.0 %	13.0 %	13.0 %	28.1 %	29.1 %

Table 14. Machine utilization rates in the packaging step for the current weekly production plan and four different scenarios

Accordingly, the machine utilization rates of the proposed scenarios are higher in many machines than the current situation. However, these rates are not sufficient to decide on how to improve the delicatessen unit. The amount of final products obtained as a result of each scenarios are important outputs to be considered at this point. Table 15 marks the amounts of the packaged products by product group in the current production plan and with different scenarios. In Table 16, the change rates of scenarios with respect to current situation on the basis of product amount are given.

	Current Weekly Production Plan	Proposed Weekly Production Plan (Scenario 1)	Adding Printer to the Proposed Weekly Production Plan (Scenario 2)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan (Scenario 3)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan and Adding Printer (Scenario 4)
Calf group products (kg)	37,995	47,798	47,798	50,129	50,129
Chicken group products (kg)	23,742.40	35,917.86	37,107.66	35,917.86	37,107.66
Turkey group products (kg)	15,800.64	18,709.44	18,709.44	35,203.2	35,203.22
Total	77,538.04	102,425.30	103,615.10	121,250.06	122,439.88

Table 15. Product group-based amounts of packaged products for the current weekly production plan and four different scenarios

	Proposed Weekly Production Plan (Scenario 1)	Adding Printer to the Proposed Weekly Production Plan (Scenario 2)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan (Scenario 3)	Increasing Freezer Speed For Sliced Salami Group in the Proposed Weekly Production Plan and Adding Printer (Scenario 4)
Calf group products (kg)	25.8	25.8	31,9	31,9
Chicken group products (kg)	51.2	56.3	51.2	56.3
Turkey group products (kg)	18.4	18.4	122.8	122.8
Total	32	33.6	56.3	57.9

Table 16. Change rates (%) of packaged products for four different scenarios compared to the current weekly production plan

Scenario 1 examined to change the production plan without changing the physical possibilities. The proposed production plan was more complex than the existing production plan and involved more waste of time due to machine washings. However, as a result of the implementation of the proposed production plan, it was determined that the amount of final product would increase by 32% in the 5-day production process. Scenario 2 considered that the production was made according to the proposed production plan in Scenario 1 and a printer was added to the packaging process. As a result, a 33.6% increase was observed in the amount of the final product compared to the current production plan.

In Scenario 3, in addition to the all the changes made in Scenario 1, an improvement was achieved in the process. In this scenario, the freezing process for sliced salami product group, which creates time loss, was provided in a shorter time. With the improvement made, an increase of 56.3% was observed in the amount of final product compared to the current program. Scenario 4 was the combination of Scenario 2 and Scenario 3. This means; in this scenario, that the production plan was changed, the speed of the freezer used for the sliced salami product group was increased, and a printer was added to the packaging process. As a result of this scenario, the amount of final product would increase by 57.9%.

As can be seen from the results, Scenario 4 achieved the maximum amount of final products with regard to the current production. Therefore, integrating this scenario into the system will provide the maximum improvement that the company expects. Furthermore, since the company's expectation is to increase the amount of products, the selection of any of the 4 proposed scenarios will still meet this expectation.

The scenarios developed in this study were determined as a result of consultations with the top management of the company. Therefore, it is possible to improve the study by trying different scenarios. In addition, it is possible to examine the scenarios in detail considering the cost factors.

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