



Pork is Chile's leading exported meat, accounting for \$467 million in shipments last year.

Turning pork into profits in Chile

A decision support system for production planning in
a Chilean swine slaughterhouse.

According to the **Chilean Office of Agricultural and Policies Studies (ODEPA)**, meat production in Chile is led by poultry, which is highly integrated and is concentrated in a small number of producers; poultry production totaled 669,054 tons in 2014. Ranking second, Chilean pork production has about 237,000 players who produce 550,000 tons or 38 percent of Chilean meat production. Beef production, with about 200,000 tons and 120,000 producers, ranks third.

Pork, however, is the main exported meat in Chile. According to the Chilean Association of Pork Producers (ASPROCER), in 2015 the value of pork meat shipments reached \$467 million. This year, the pork sector constituted 60 percent of Chilean exported meat, and the trade balance was positive for the sector, exceeding \$350 million. The leading destination of pork exports is South Korea with 30 percent, followed closely by the People's Republic of China.

By Marcela C. González-Araya

Due to the growth of the Chilean pork industry in recent years, the sector has made an effort to maintain its international competitiveness and export to the most demanding markets in the world with high standards of quality and safety, such as Japan, South Korea and the European Union (EU) in order to compete with the world's largest exporters, led by the United States. This growth in exports has increased the complexity of the swine industry in Chile, forcing companies to become more specialized and dynamic in order to adapt to the changes and to maintain profitability over time. However, many Chilean companies are unable to react efficiently to these changes.

Because of this new situation, one Chilean pork company was interested in developing a decision support system (DSS) based on optimization models for planning production, inventory and storage operations in its slaughterhouse. In this way, the company wanted to improve its plant efficiency and control, and to reduce meat losses, as well as the length of the decision-making process.

The company, the fourth largest pork producer in Chile, devoted its efforts to the production, slaughter and export of pork. It is located in the south-central region of Chile and belongs to ASPROCER.

The company's slaughterhouse currently includes 350 direct employees and 150 indirect employees and processes about 300,000 pigs with a meat volume of 30,000,000 kilos a year. The plant has 10 chilling tunnels with a capacity of 200 tons, six chill rooms for carcasses and one cold storage with capacity of 1,200 tons.

For the development of the DSS, the slaughterhouse manager contacted the author from the Department of Industrial Engineering, Universidad de Talca, Chile, and her master's degree student in operations management, Rodrigo Sánchez-Ramírez, who was doing his thesis based on a slaughterhouse production planning problem of the company.

The DSS development was possible through a project for promoting productivity and competitiveness of the Chilean industry, where approximately 80 percent of the funds came from the state (Development Corporation of Production - CORFO), and the remaining amount came from the company. González-Araya was the director of this project and was in charge of its implementation, which lasted 30 months and was started in March 2012. Besides the director, the project team consisted of five engineers: two industrial engineers (Ariel Bustos-Véliz and Wladimir Soto-Silva), one computer engineer (Juan Monsalve-Martínez) and two engineers expert in swine processes (Rodrigo Sánchez-Ramírez and César Rodríguez-Muñoz).

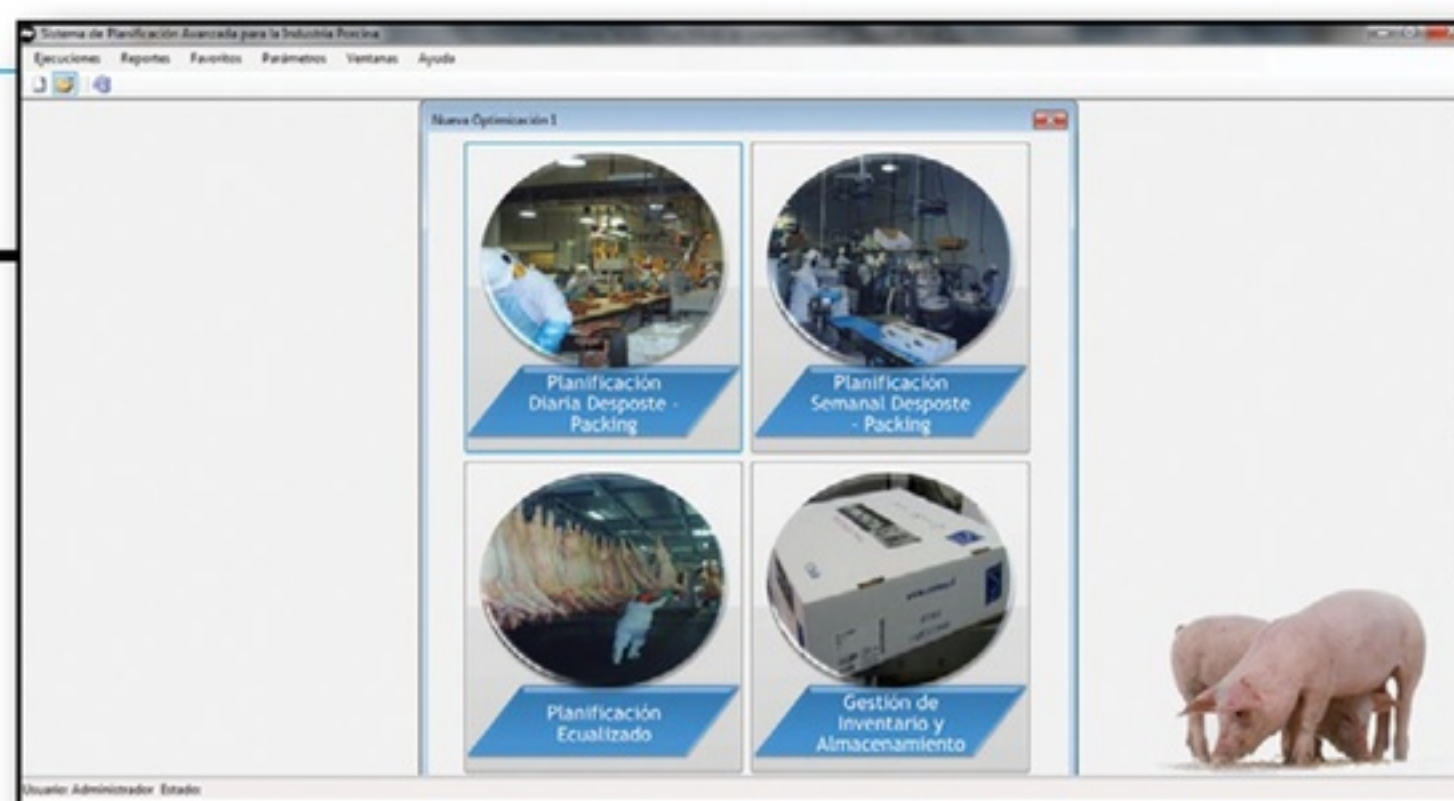


Figure 1: Screen of planning options for improving production processes.

The stages for the DSS development were: data collection and diagnosis of slaughterhouse production processes; models formulation, solution and validation; and design and implementation of DSS.

Production Planning in the Slaughterhouse

As evidenced in practice, Chilean swine companies have not invested in infrastructure to increase production capacity in proportion to the demand increase. Therefore, they had to focus on improving production practices, as is the case of the company where the DSS was developed.

In recent years, the company's exports have experienced sharp increases, as have the number of offered products. As an example, the variety of products increased from 50 in 2007 to 400 at present, thus increasing the complexity of coordination activities. Because of this, the slaughterhouse professionals stated that, despite having international markets required certifications, a computer system for process optimization was necessary in order to support decision-making production and logistics in the pork value chain. The lack of this tool meant that the time required for obtaining production planning estimates were high, involving breach of contracts by production delays and loss in product quality, among other issues. The complexity was compounded, because the product is highly perishable.

Before the DSS implementation, two engineers carried out the production planning. Once a week,

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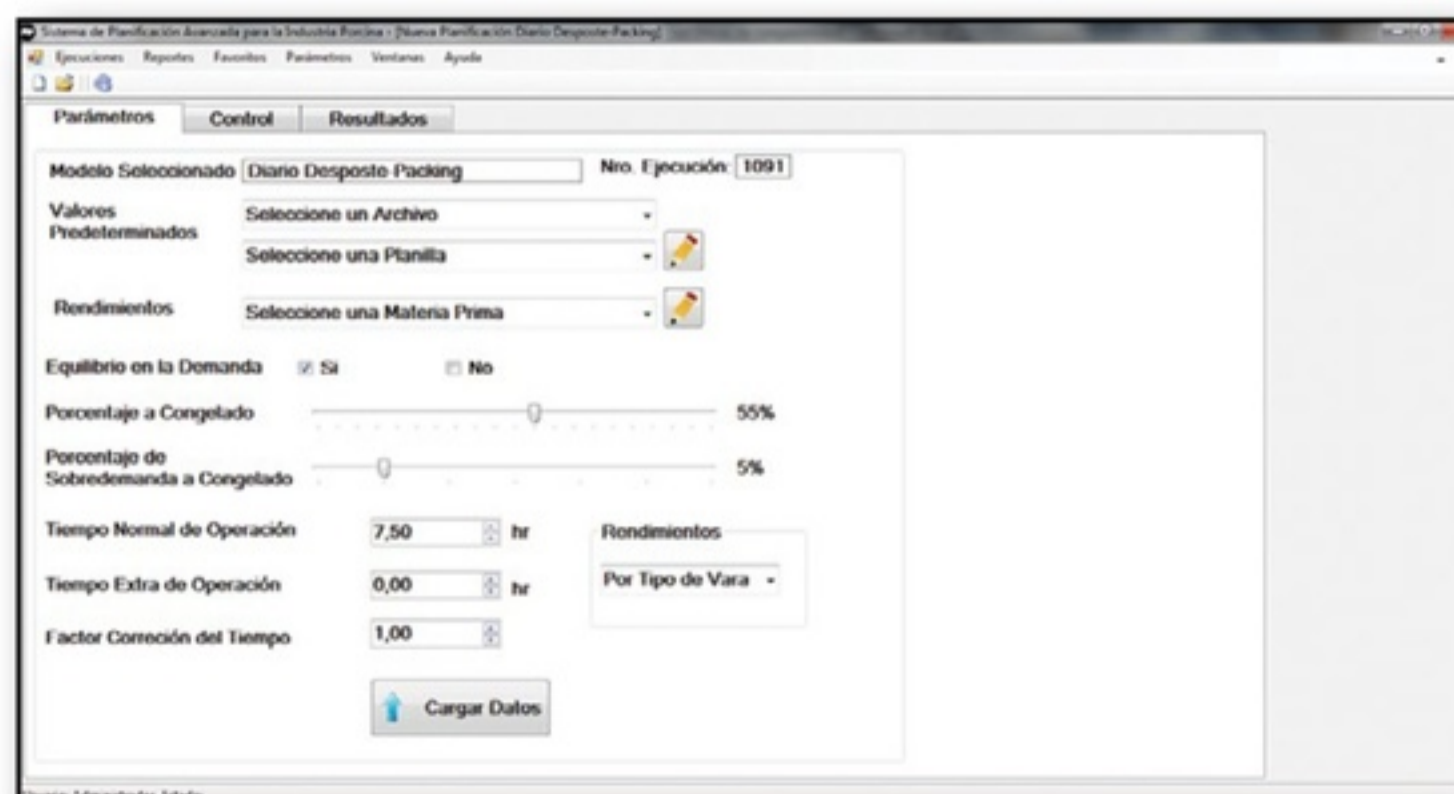


Figure 2: Data entry screen for daily planning model.



Pork production planning

they took more than three hours to obtain a weekly schedule. This schedule considered one planning scenario. In addition, the company had a professional in charge of reviewing daily changes in the assumed data for planning. This way of planning did not allow the company to react quickly to reschedule production due to unforeseen circumstances, a common situation because of the variability of markets. Nor did it allow for sensitivity analysis of critical data used in planning. This situation is similar with other Chilean companies

in the swine industry. Because of this, the client company decided to automate production planning, aiming to also reduce the time for doing weekly and daily scheduling.

Additionally, like other industries, the swine industry is highly sensitive to the raw material productivity (final weight/live weight). Actual yields of productive tasks were unknown for the company, i.e., there were no estimates of yields according to different cuts (products and by-products) and pig varieties (kg/pig), so it was unknown if the pig allocation for obtaining the different cuts was efficient, hindering the reduction of raw material losses. For this reason, the DSS also incorporates records of production inputs and outputs (products and by-products), making it possible to obtain yields by pig breeds and kind of cut, as well as production analysis reports.

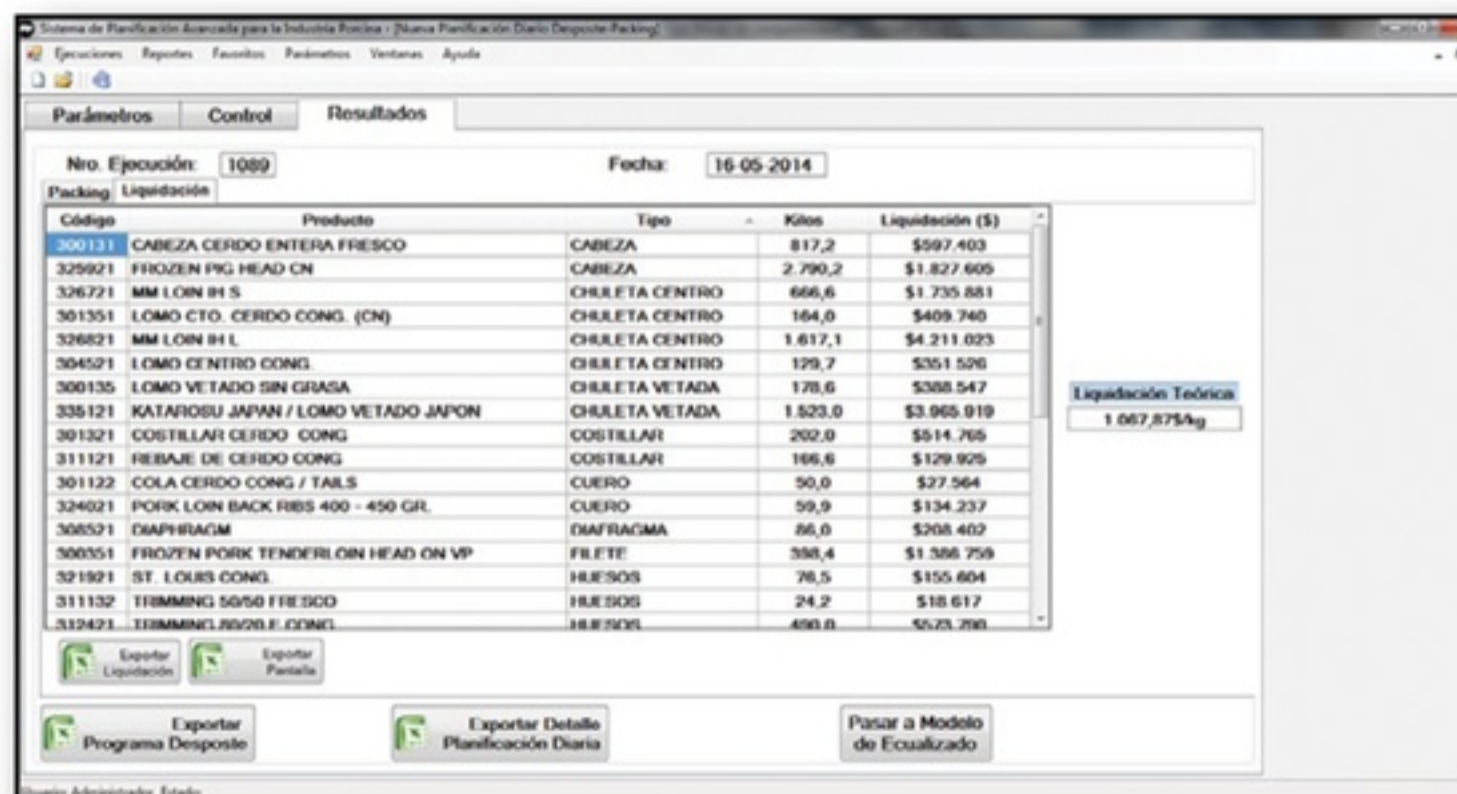


Figure 3: Products profit screen obtained by daily planning model.

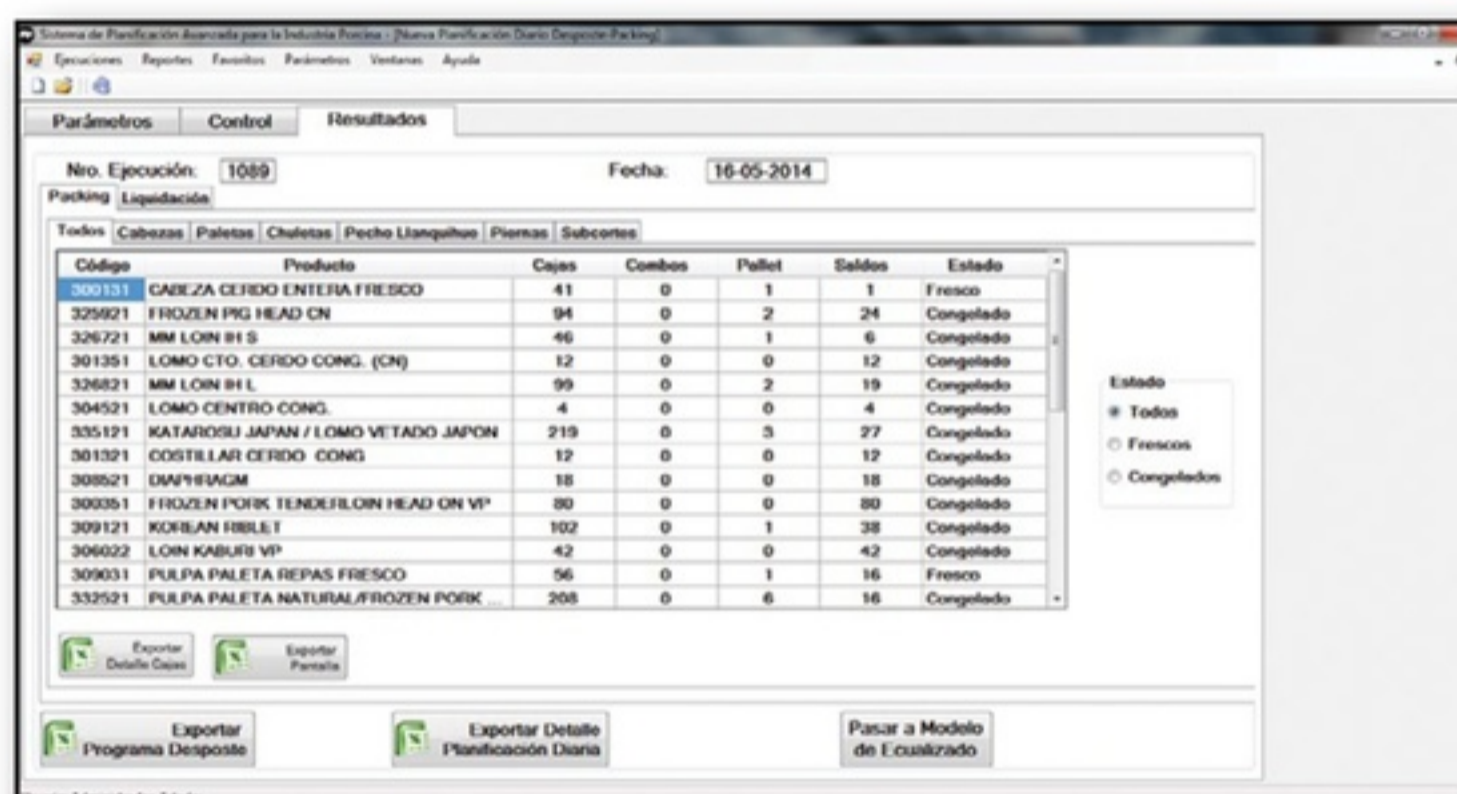


Figure 4: Products packing screen obtained by daily planning model.

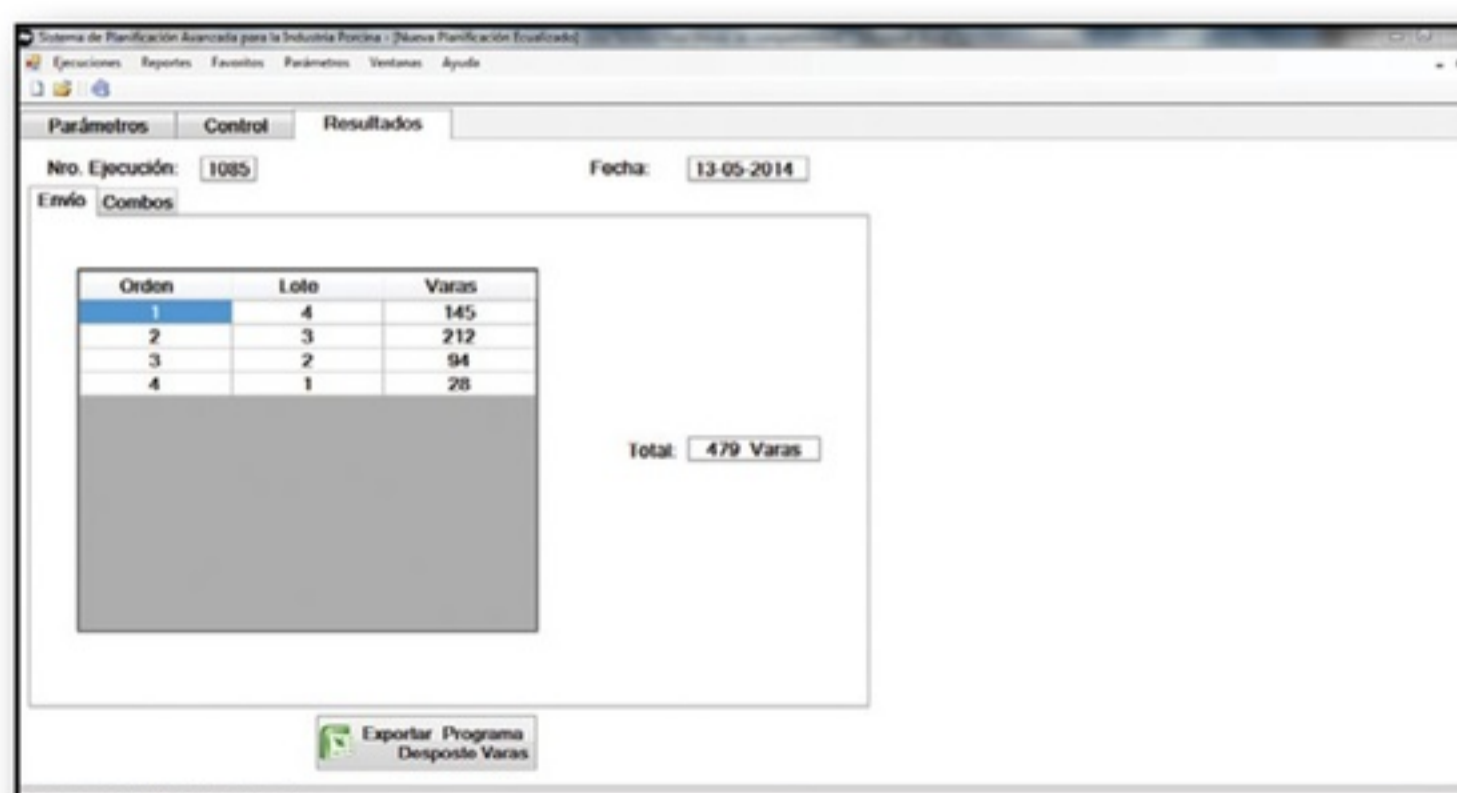


Figure 5: Batch sequence screen obtained by the model of chilling system management.

DSS for Advanced Planning Production

The DDS was designed to support operational decisions in a swine slaughterhouse, aiming to minimize costs of production, storage and meat losses. For this purpose, four optimization models were developed; each one was associated to a DSS module (see Figure 1). The optimization models are the following: daily planning model of cutting and packing; weekly planning model of cutting and packing; model of chilling system management; and model of storage management. As is seen in Figure 1, the user (slaughterhouse manager) can choose the planning option he/she requires to do.

The language used to program the DSS interfaces was Visual Studio 2010, and the optimization models were run in commercial software bought for this implementation.

For running the daily planning model of cutting and packing, it was necessary to do a data collection for estimating yields according to different cuts and pig varieties. Therefore, two interviewers were hired and a sampling design was performed in order to obtain robust yields estimations. This activity demanded more time and resources than other project activities. On the other hand, the required information for running the other models of DSS was available in the company's information system.

The daily planning model of cutting and packing allows the decision-maker to schedule the number of pork carcasses to use according to its weight and kind of cuts to produce, the kilograms of products and by-products obtained in normal time and extra time, the number of box and pallets to use, the unsatisfied demand kilograms of products and by-products and the products' profit. Previously, the decision-maker had to update data representing the

current state of the plant as demands, costs, operation times and chilling capacities. Figure 2 shows a data entry screen where the main of parameters are set by default. The user can change these parameters according to daily production requirements. Figure 3 presents the profit screen by product, and Figure 4 shows the number of box, pallets and remainder by product obtained with the daily planning model. All these results can be exported to an Excel file.

The weekly planning model of cutting and packing allows the user to estimate shipment date per customer, days late per customer, state of shipment per customer (ready or pending), number of carcasses to use by product in each shift, kilograms of products obtained per shift, kilograms of products shipped each day and kilograms of products in cold storage each day. The weekly and daily models are complementary since the weekly model allows an ideal production planning, and the daily model allows a reschedule based on changes that may occur during the week.

According to the results obtained from the daily planning model, the model of chilling system management seeks to schedule the entry of pig batches from the chill room to the slaughter room in order to improve efficiency of slaughter and packing processes and to reduce downtime. Hence, this model proposes, besides the pig batches entry sequence, the carcasses number to use per batch and by product, and the maximum number of products to yield per batch. Figure 5 shows the batch sequence and number of carcasses used in a day for achieving products demand.

Finally, the model of storage management organizes the products in the cold storages according to their class: ham family, loin, ribs and bellies, shoulder family and pork sheet. The model assigns the aisles to use by class, the name, code, class and position for each pallet, and the positions number to use per cold storage.

Conclusions

For developing the DSS, one of the main difficulties was to form the team, especially to find a computer engineer that understands optimization models and to hire industrial engineers able to program advanced routines. Therefore, for future projects, we recommend estimating the learning time of developers.

Besides the DSS implementation, an important contribution of this project was the yields estimations. These estimations also can be used in any Chilean company if it does not have the data, and the methodology for obtaining this data can be replicated. In addition, it is very common that compa-

ITEM	DESCRIPTION	VALUE (USD)
Fulfillment with foreign customers	4% of annual production	1,208,944.43
Increase of profit margin	USD 0.005 per live kilogram	2,266,770.08
Reduction of inventory stocks	0.10% of current production	10,804.94
	Total Annual Profit	3,486,519.45

Table 1. Estimated annual profit with DSS implementation

nies do not register all necessary data for making decisions. On the other hand, companies usually collect data through information systems that are not used in any kind of analysis and do not carry out business intelligence.

It is noteworthy that the formulated models can be adapted to other swine companies in a short time.

During this implementation, the company realized that some production processes could be improved and formalized, thus introducing changes in its practices. This kind of development makes it possible to identify inefficient tasks that can be corrected without investment in new technology.

Among the results for improving production planning, higher profit margins were obtained, reaching increases of half a cent (U.S.) per live kilogram, an important contribution in an industry of low profit margins.

Other indirect results perceived by the company with the DSS implementation are:

- Decrease of foreign customer loss for non-compliance. Each foreign customer loss generally amounts to USD 0.03 per meat kilogram, assuming it can be sold in the domestic market.
- Reduction of inventory stocks around 0.10 percent, due to the weekly schedule that allows a better control in the cold storages and optimizes how to complete the products shipments.
- All these improvements imply an annual increase of profits around \$3.5 million as calculated in Table 1.

Future development of the DSS is to interact directly with the company's information system instead of reading entry data from Excel files. The use of Excel files was suggested by the company's managers because of some apprehensions about the information system manipulation. **ORMS**

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REFERENCES

1. ASPROCER: Chilean Association of Pork Producers, <http://www.asprocer.cl/>
2. ODEPA: Chilean Office of Agricultural and Policies Studies, <http://www.odepa.gob.cl/>

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