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TECHNICAL NOTE

# THE LEVEL OF AUTOMATION OF "CARASAU" BREAD PRODUCTION PLANTS

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## 1. Introduction

The food industry, and in particular small traditional bakeries, must supply the market with high quality safe products if they are to meet consumer needs. This means adopting standardised and trustworthy production methods. The most recent data on the Sardinian bakery industry is from 2002 to 2004. This showed that work units increased by 17% and that the total income was € 73 million. The increase in the workforce is due to the increased demand for the product both nationally and in Europe in general. Although certain levels of automation have been reached, today significant parts of the process are still done manually. This is particularly true in the cutting and separation of the puff pastry, which is mainly done either by hand or with the help of small machines. These operations have a great impact on the total labour time used to make the product, increasing it on average by 50% [1,2,3]. This has encouraged research into the use of experimental methods designed to increase the overall levels of automation [4]. The present situation means that changes can no longer be delayed if the qualitative and quantitative needs of the market are to be satisfied. This means that traditional bakeries must rationalise their plants, in particular in certain phases of production, and also that the machines used must be improved in order to meet the demands of the clients. Specific studies are required in the sector which bear in mind the needs of the of the workers, so that correct criteria are used when making choices on what type and size of plant should be used and alsowhen deciding which new methods should be used.

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This work investigates three types of bakery in order to calculate and compare the labour hours used, the workforce employed, the quantity of bread produced, and the potential capacity. It focuses in particular on the cutting and separation methods used in the three plants.

## 2. Materials and methods

### 2.1 *Hand made preparation of "carasau" bread*

Pane carasau" or "carta da musica" (sheet music) (figure 1) is circular, from 30 cm to 45 cm in diameter, and 0.7 to1.0 mm thick. It is crisp, without any soft white segment, and can be conserved for from 4 to 6 months [5,6]. The production process is divided into the following phases.

The product is prepared by kneading, first separation and the beginning of fermentation, second separation, and final fermentation. The discs of "pane carasau" are then formed, pressed and baked and the two sheets obtained are separated by hand. The "carasatura" or second baking then takes place to obtain the finished product. Finally the products are wrapped in paper or in plastic film suitable for food products.

Fig. 1 - The "carasau" bread after the second baking.

| PLANT | | | | |
|---|---|---|---|---|
| (type) | Dough Mixer | System | | Oven |
| | | cutting | separation | |
| Traditional | fork | hand | hand | tunnel |
| Traditional with conveyor belt | fork | hand + conveyor belt. | hand + conveyor belt. | tunnel |
| Continuous | spiral | automatic | automatic | tunnel |

TABLE 1 - Technical and operational characteristics of the plants.

Fig. 3 - Tunnel oven used for baked the "carasau".

## 2.2 C*haracteristics of the plants*

The following plants were studied:

a) Traditional: knives used to separate the sheets and a workforce of 8 persons.
b) Traditional: again 8 workers, but the cooling, cutting and separation operations were served by a conveyor belt which carried the material to the work station;
c) Completely automated and continuous: a conveyor belt was used to supply the workstations with one worker loading the sheets on it, and three workers were employed in cutting and separation, using a circular cutting system.

All three plants (table 1) used mechanical dough mixers to mix the dough, mechanical cutters for the separation of the leaves, mechanical formers (figure 2) for forming and electric tunnel ovens for baking (figure 3). In the traditional plant the disks of "pane carasau", were pressed by hand as soon as they came out of the oven, in order to eliminate the humidity released by the product during baking. They were then placed in a plastic or wood tub to cool for a few minutes. The bread was then taken out by two workers and distributed among eight workers around a table who cut and separated the sheets by hand (figure 4). In plants with conveyor belts (figure 5) after baking one worker placed the disks on top of one another, and, after they had cooled, eight workers removed the sheets and cut and separated them by hand. The continuous plant had a prototype machine which was used after baking.

The "pane carasau" was loaded by hand onto a double belt system. The leaves were slowly and continuously pressed as they moved between these belts to remove swelling. The product then moved to the second worker who operated a cutting machine (figure 6). This consisted of a rotary cutting cylinder with knives on its circumference which cut the bread 7 mm from its edge and so produced the discs. A jet of high pressure air played over the sheets to remove the debris from cutting. The two halves of "pane carasau" were separated by two suction bells and the stacks returned to the oven for the second baking. In all four workers were used in this plant for the cutting and separating operations.

Fig. 2 - Moulding machine used in the preparation of the disks of "carasau" bread.

Fig. 4 - Hand cut of the "carasau" bread.

Fig. 5 - "Carasau" bread on the conveyor belt before separation by hand.

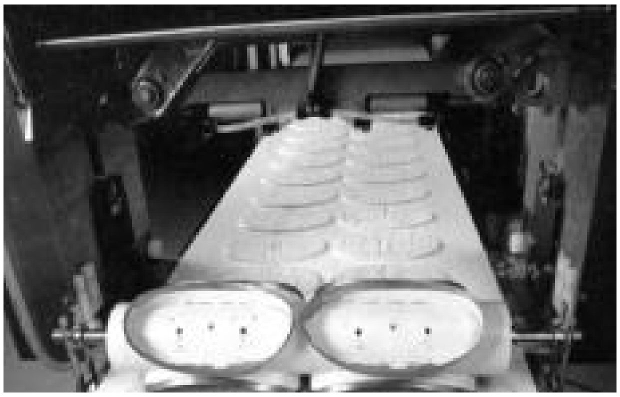

Fig. 6 - a rotary cutting cylinder was used for cutting in the continuos plant.

## 3. Methodology

The work time for cooling, cutting, separation, and finishing the product was measured in the three plants for each single operator, as well as the number of pieces produced and the quantity of the final product. This data was then used to calculate the capacity of the plants and the productivity of the workforce. The temperature of the product when it left the oven, on the work tables and on the conveyor belts was also measured, using a Raytek "ranger MX 2" infrared thermometer.

## 4. Results and discussion

### 4.1 *Work time*

A comparison of the work time in the three plants (table 2) shows that 6.6% of total work time was used for cutting in the continuous plant, which was 26.6% of the time used in the traditional plant. In the latter 51.2% of total work time was used for cutting and when separation is added to this the figure reaches 92.3%. In the traditional plant with a conveyor belt the situation was slightly worse. 54.7% of total work-time was used for cutting compared to 6.6% in the continuous plant.

In these two plants, by contrast with the traditional plant, the time for separation was less. Separation took 6.9% of total time in the traditional plant with a conveyor belt and was even less that that in the continuous plant13.2%. In the traditional plant the time taken for cutting and separation was effected by the time taken for the sheets to cool at room temperature,

| Plant | Workers | Used daily | Time used | | | |
|---|---|---|---|---|---|---|
| | | | Cutting | | Separation | |
| (type) | (No.) | (h) | (h) | (%) | (h) | (%) |
| Traditional | 8 | 4 | 2.05 | 51.2 | 1.64 | 41.1 |
| Traditional with conveyor belt | 8 | 12 | 6.56 | 54.7 | 0.83 | 6.9 |
| Continuous | 4 | 8 | 0.53 | 6.6 | 1.06 | 13.2 |

TABLE 2 - Working time and time percentage in the phases of the production.

especially as these operations took place in the same room as the oven. There was a considerable reduction in the temperature from leaving the oven at 150°C to 87°C on the work table, but this was still high and slowed down the actions of the workers.

In the traditional plant with a conveyor belt, the belt was fitted with fans with infrared sensors. The sensors triggered off the fans as soon as the discs left the oven. These were rapidly cooled to less than 60°C which improved the work conditions for cutting and separation. In the continuous plant the time for separation was affected by the fact that the workers had to remove the waste from some sheets because the machine did not separate them perfectly.

### 4.2 *Work capacity*

The overall work capacity and productivity of the individual workers in the three plants (table 3) varied according to the system of cutting and separation used and also according to the number of workers. Total productive capacity increased with the level of mechanisation, from 25.00 kg/h in the traditional plant to 43.30 kg/h in the traditional plant with conveyor belt and 100.00 kg/h in the continuous plant. This difference is even more pronounced in the phases of cutting and separation. In the continuous plant the capacity was 1509.43 kg/h for cutting and 754.72 kg/h for separation. These values were much higher than those in the traditional plant (48.78 kg/h for cutting and 121.95 kg/h for separation).

When the traditional plant with the conveyor belt was compared to the continuous plant, the figures were markedly worse only for cutting (79.20 kg/h), while for separation they were much better, reaching 626.02 kg/h. The traditional plant with the conveyor belt increased the productive capacity of the individual worker by 62.30% when compared to the traditional plant. Obviously the traditional plant cannot be usefully compared with the continuous plant because in the former all work is performed manually while in the latter machines are used. Indeed productivity increases from 6.10 kg/h-worker to 377 kg/h-worker or in other words by 618%.

| Plant | Work Capacity | | | | | |
|---|---|---|---|---|---|---|
| | Total | | Cutting | | Separation | |
| | plant | workers | plant | workers | plant | workers |
| (type) | (kg/h) | (kg/h-ad) | (kg/h) | (kg/h-ad) | (kg/h) | (kg/h-ad) |
| Traditional | 25.00 | 3.13 | 48.78 | 6.10 | 121.95 | 15.24 |
| Traditional with conveyor belt | 43.30 | 5.42 | 79.20 | 9.90 | 626.02 | 78.25 |
| Continuous | 100.00 | 25.00 | 1509.43 | 377.36 | 754.72 | 188.68 |

TABLE 3 - Work capacity of the plant and workers.

## 5. Conclusions

The results clearly show that there are marked differences between the plants and in particular between the continuous plant and the other two. The differences are particularly evident in the cutting and separation phases. These are normally the phases where productive capacity is lowest, and this obviously affects the productivity of the individual worker. Indeed the parts of the process where automation had not reached optimal levels, such as cutting the leaves of "carasau", particularly penalised the plants which had higher levels of automation in the preceding phases. It also had a negative impact even in the traditional plant, which could not supply customers' needs, especially during the periods of maximum demand.

The study showed how the percentage of time spent on cutting, 6.6% of total time, was far less in the continuous plant than in the others. The time spent on this operation was 51.2% in the traditional plant with the conveyor belt and 54.7% in the traditional plant. Our results show that the time spent cooling the product after the first baking was of particular importance. It severely affected the following operations because the temperature of the leaves prevented the workers from going to work immediately. This could be avoided by introducing a system which blows cold air over the product in the other two plants. This would help to separate the sheets. Thus the introduction of the prototype cutting machine in the continuous plant had an appreciative effect on the performance of the workforce, by both reducing the numbers of workers employed in this activity and improving their productivity. In fact the simple introduction of the conveyor belt in a traditional plant significantly increased the capacity of the individual workers (by 42.3%) and reduced the percentage of time spent on separation compared to the traditional plant without the conveyor belt, with advantages for the whole process. In the continuous plant automation of cutting and separation markedly reduced the percentage of time spent on these operations. It also made it possible to maintain production at a constant level, even when the working day was reduced.

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SUMMARY

Currently, the lowest productivity of workers involved in the production of the "carasau bread" is in those plants where automation has still not reached optimal levels in certain parts of the process, such as, for example, in the cutting and separating of the puff pastry. In the present work we analyse and compare the performance of three systems of cutting and separating in three different types of plant: by hand (traditional); by hand with a conveyor belt that supplies the workers with the material (traditional with conveyor belt) and completely mechanized (continuous). The experiment showed that the use of an automated system of cutting supplied from a conveyor belt reduced the time of the cutting phase for puff pastry by 87.1% with respect to hand cutting supplied by conveyor belt and by 87.9% with respect to the traditional system. If we consider the hourly productivity of the workers, we see that use of a conveyor belt increases productivity in a traditional bakery by 42.3%, while the use of the continuous system increases productivity by 87.8% compared to the traditional system and by 78.3% with respect to hand cutting supplied by conveyor belt.

**Key words:** "carasau bread", cutting and separation, automation.