Design of bakeries for the production of traditional Sardinian *carasau* crisp bread: features of the building and plant engineering

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Abstract

In this work the authors propose a method for the proper design of bakeries for the production of traditional Sardinian crisp bread known as *carasau*.

After examining the flow chart, they turn their attention to the sectors for raw materials (water, semolina, yeast, malt and so on), the production machinery and accessories (silos for storing the flours, fermenters, kneading machines, rollers, baking ovens and so on), spaces for manoeuvring and service areas for operators.

The study of the interconnections between the single elements leads to the idea of a plant and building layout which, depending on plant potential, can be applied to different production requirements. In this sense and as an example, the authors propose three typologies, all equally valid from the functional standpoint, but different as concerns architecture.

Keywords: design, traditional bakery.

Introduction

The food industry in general and in particular the small traditional bakery industry must supply the market with high-quality and safe products to meet the needs of consumers and at the same time must adopt standard and reliable procedures.

From the latest data available it emerges that in the two-year period from 2002 to 2004, Sardinia's baking industry saw a 17% increase in the number of persons employed, with an annual turnover of 73 million euros. The increase in employment is to be attributed to the increase in demand for this product on the national and European scales; despite the level of automation reached, this industry still presents a significant number of persons employed. From this arises the need to perform specific studies that take into account the needs of operators in relationship to the introduction of more efficient machinery and indicate solutions for buildings and plant engineering leading to an improvement in the efficiency of bakeries also through the design of specific layouts. For this reason it was considered important to study the problems connected with the setting up of small, efficient bakeries with the objective of finding certain objective criteria to which to refer, above all to avoid what has occurred in other sectors of the food industry, where spontaneous developments in plants and technology (wineries, oil presses and so on) have not always been accompanied by the necessary study of the buildings that house them.

Buildings for the production of *carasau* crisp bread

The drawing up of a plan for the production of *pane carasau* must therefore take into account first of all the organization of the production cycle by means of a detailed study of the single stages that characterize it and then verification of the activities that directly or indirectly enter into processing.

The study of the organization of work makes it possible to identify the functional areas that must be dimensioned to receive and store the raw materials (water, flour etc.), the machinery necessary for production (ovens, fermenters, mills, filters, pumps and so on), storage containers with their accessories, as well as spaces for manoeuvring and service areas for operators.

The work cycle and layout of the building impact on the routes and interdependencies between the single sectors so as to arrive at the definition of dimensional standards.

In the same way, the study of interconnections between the single elements provides an approach to the schematic layout of the building.

Raw materials

The main raw materials used in the production of *pane carasau* are water, malt and yeast.

Work cycle

Technology for the production of *pane carasau,* also known as *carta da musica* ("musical bread") goes back to ancient times and has come down to us with relatively few changes in how it is made. The process includes the following stages: kneading, a first rolling out and beginning of fermentation, a second rolling out and then final fermentation. These stages are followed by shaping and cutting of the disks of *pane carasau;* then come the baking and separation by hand of the two layers obtained and then the *carasatura,* or second baking or finishing, of the end product. Production concludes with packaging in paper or plastic films for foodstuffs.

Plant 1 (Traditional)	Plant 2 (Simplified traditional)	Plant 3 (Continuous)
Spiral or fork bench blender	Planetary mixer	Planetary mixer
Roller and forming machine	Roller and forming machine with conveyor belt	Roller and forming machine with conveyor belt
1st Baking in a wood oven	1st Baking in a tunnel oven	1st Baking in a tunnel oven with automatic feed
Cutting and separating by hand	Cutting and separating by hand	Cutting and automatic separating
Carasatura (2nd baking) in a wood oven and packaging by hand	*Carasatura* (2nd baking) in a tunnel oven and packaging	*Carasatura* (2nd baking in a tunnel oven with automatic feed and automated packaging

Table 1. Work cycles with different levels of automation for different types of plants

Plants and equipment

Plant engineering for an efficient plant for the production of *pane carasau* is essentially composed of the following equipment:

- Storage silos (for semolina and water)
- Dosing machine
- Planetary mixer
- Fermenters
- Conveyor belt
- Rolling machine

- Shaping machine with conveyor belt
- Tunnel oven
- Automatic separators of the two halves
- 2nd tunnel oven (optional)
- Packaging machine

In traditional bakeries and those with a low level of automation the plant design can be further simplified by eliminating the conveyor belt rather than the shaper or the separator.

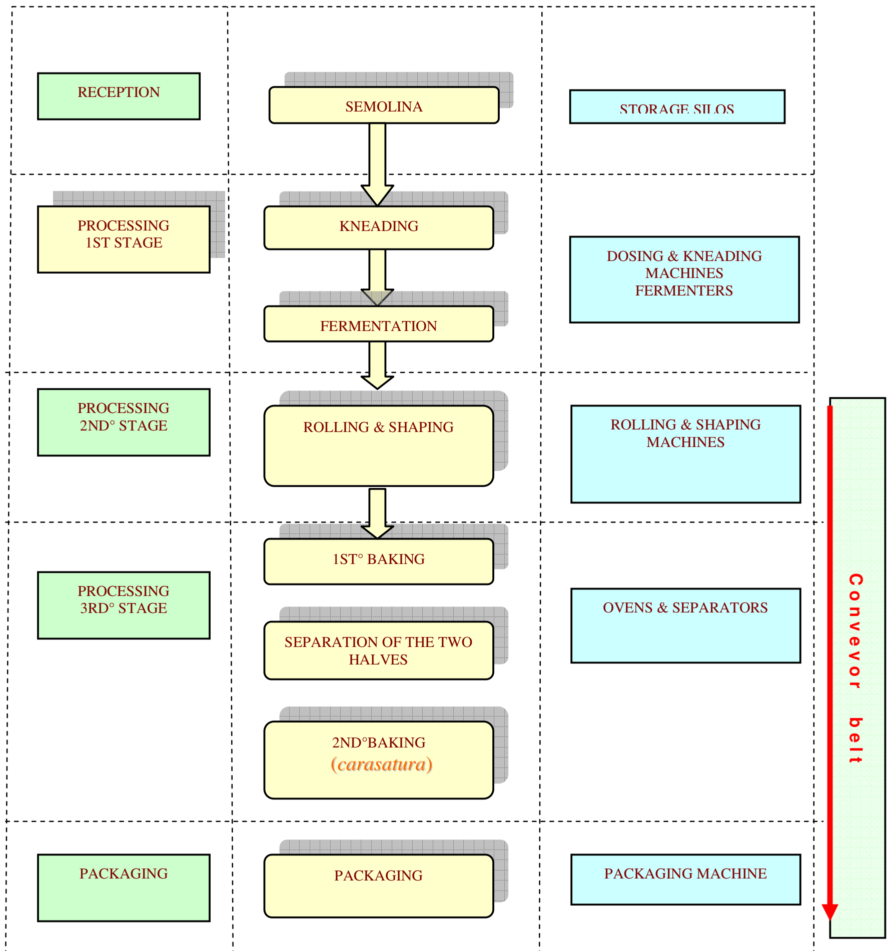

Diagram 1. Functional areas, work cycle and plant engineering in a small bakery

Planning method

Having studied the preliminary issues, it is opportune to proceed in the proper way through the design stage of a bakery by addressing the problems with a logical and consecutive order of priorities:

1. study of the production plan for a bakery having a potential of 300 kg/day;
2. overall consideration of problems involved in implementation and the subsequent preliminary stage of the project;
3. development of the various parts of the project from the functional and distributive

profile;

4. elaboration on the basis of the chosen production cycle of the numerical values concerning times and production with respect to initial amounts of raw materials and potential in terms of kilos per week;
5. choice of production machinery and storage containers on the basis of plant potential and all the other issues previously examined.

Thus we can state that the functional and organizational elements that go into the definition of a building structure for the production of *pane carasau* can be summarized in the following points:

a) ***work cycle***
- Dosing of ingredients,
- Mixing,
- First rolling and beginning of fermentation,
- Second rolling,
- Final fermentation,
- Shaping and cutting of the disks of *pane carasau*,
- Baking,
- Separation by hand of the two layers obtained,
- Carasatura or second baking or finishing of the final product,
- Packaging.

b) ***definition of the functional sectors and the relative areas of:***
- storage of raw materials,
- mixing, first rolling and beginning of fermentation,
- second rolling, final fermentation and cutting of the disks of pane carasau,
- baking and separation by hand of the two layers obtained,
- carasatura or second baking (finishing) of the end product,
- packaging.

c) ***operating spaces for:***
- machinery and equipment,
- products,
- operators.

d) ***microclimatic and environmental needs.***

The production plan

The hypothesis for a bakery arises from a feasability study justifying its creation on the basis of the demand for traditional bread both in Sardinia, with noteworthy increases in the holiday season owing to the favour it enjoys among Sardinia's many visitors, and in the rest of Italy's larger market where it is now possible to find *pane carasau* all year round on the speciality shelves of supermarkets.

The necessary plants

To make the proper choice of equipment and establish the relative operational capacity, we drew up an executive plan by means of which it is possible to verify at every step the state and amount of product and the plants involved.

Through the study of the production cycle it is possible to dimension the necessary processing and storage plants and at the same time make a functional choice with respect to processing needs.

In detail the plants consist of:

- 1 stainless steel water tank, AISI 316, diameter 1.2 m, capacity 1000 litres
- 1 cloth silo for storage of at least 1000 kg of durum wheat semolina
- 1 water/semolina dosing machine, capacity 100 litres
- 1 planetary mixer, capacity 100 kg/hr
- 2 fermenters, capacity 80 litres each
- 1 shaping machine for disks of dough
- 1 conveyor belt, 10 m in length
- 1 rolling machine
- 1 tunnel oven
- 1 automatic separator of the two halves
- 2nd tunnel oven (optional)
- 1 controlled atmosphere packaging machine
- heat pump for conditioning of some areas
- forced-cycle air extractor with antibacteria filter
- 1 air compressor, capacity 200 l/min, max. pressure 10 bar
- 1 command and control electric panel
- pipes, accessories, ball and butterfly valves and so on.

Functional areas

The production structure must have the following functional areas:

- an area for storage of raw materials
- a fermentation area
- a rolling and shaping area
- an area for first and second baking
- a packaging and temporary storage area
- accessory areas

area for storage of raw materials

This is where raw materials, basically semolina, malt and water, are stored in steel and cloth silos. The surface of this area may be more or less large depending on the supplies to be kept on hand; when there are no local distributors of raw materials the area must be larger since the number of deliveries will be limited, with larger amounts delivered; if there are distributers nearby, the area may be smaller.

To be kept in mind is that this sector must be sealed and protected from humidity and parasites (insects and rodents).

fermentation area

Here is where we find the dosing machines for the automated preparation of the dough, the planetary mixers and the fermenters, together with auxiliary plants such as the heat pump required to control temperature and relative humidity.

rolling and shaping area

This can be adjacent to the previous functional sector since the activities performed here call for temperature and humidity conditions similar to the fermentation area. In this sector we have the rolling and shaping machines.

area for first and second baking

This represents the most characteristic sector of the bakery, since it is here that we find the tunnel ovens in which the first baking takes place, followed by separation of the two layers which inflate like a balloon during baking; after separating the two layers they are left to cool and then baked a second time, the so-called *carasatura*, which gives the bread its characteristic shape of a rigid disk.

packaging and temporary storage area

After *carasatura*, the disks are packaged in bags and stored temporarily awaiting delivery to customers. In this area there is to be a packaging machine, also one with controlled atmosphere, and a series of shelves to temporarily hold the packages ready for delivery.

accessory areas

Here we have areas not closely connected with the production cycle, such as hygienic fixtures, dressing rooms, offices, heaters and air conditioners.

Functional arrangement

The first case, the simplest one, consists of maintaining the linearity of the flow chart by constructing a building with linear, rectangular modules, with entrance and exit opposite to one another situated on the two short sides. Among the advantages of this solution we have above all the simplicity of design and the full efficiency of the process since there are no obstacles between the different stages; among the disadvantages, the most important one is occupation of a large surface, with the consequent increase in volume and costs which can be offset only in the case of industrial production or in special cases in which no other solution is possible.

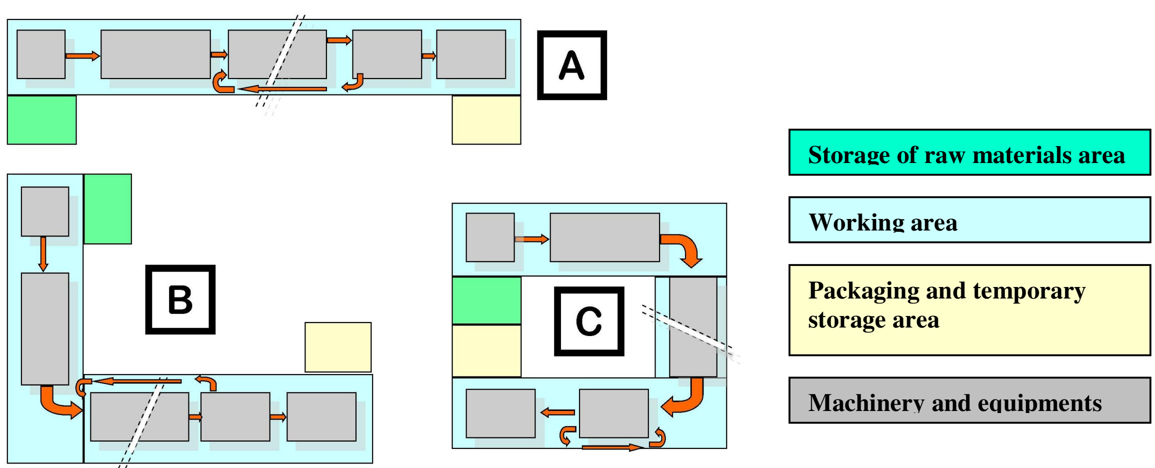

Figure 1. Possible functional configurations: A linear; B "L"- shaped; C circular

The second solution can be defined as an **"L"** or "**U"** configuration depending on whether the flow chart is divided into two or three segments respectively. Also in this case, as in the previous one, there are advantages and disadvantages: among the former we have the reduction in volume of the building and building costs; among the latter we have the presence of greater risks of obstacles owing to the presence of curves and junctions that lead to the creation of points common to two processes in the same module.

The third solution is represented by a ring in which, apart from the shape of the building, there is a circular movement of production with the entrance and exit (of raw materials and final products) that coincide. This design is undoubtedly the least expensive, but it imposes organizational limits that cannot be overlooked, thus it is suitable for situations where economic capacity is limited.

Final considerations

The development of the subject leads to the following interesting conclusions:

- The necessary plant and equipment, although rather expensive at the time of purchase, are certainly of long duration thanks to the materials they are made of; they are easy to work with and clean and, for the type of plants examined herein, this work can be done by a single worker.
- The plant layout, once the needs of the specific work cycle have been satisfied, leaves great freedom in arranging the different functional sectors, the operative areas, the pathways and interdependencies, thus favouring a high standard of quality and genuineness.
- The layout allows a good degree of flexibility in use considering that for special market requirements it is possible to produce traditional bread of the *spianata* (flat) type with few changes to the plant.
- The buildings for use with this kind of bakery are fairly simple and the consequent floor plans do not create excessive difficulties from the structural standpoint.

In conclusion, we can state the validity of an initiative in this sector, keeping in mind that effective planning must include a careful analysis of every aspect of the work cycle adopted.
It is therefore auspicable a more widespread diffusion of these plants, realistically conceived for small and medium production units, which are reliable, simple and relatively cheap, as well as being capable of growing in step with a hopefully growing demand.

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