

## **EIT Food - EU PRO4BAKE project: Improve artigianal bakeries performances considering both demand forecast and process optimisation: the EIT FOOD Pro4Bake approach**

Remigio Berruto<sup>1\*</sup>, Sara Beduschi<sup>1</sup>, Botta Giulia<sup>1</sup>, Patrizia Busato<sup>1</sup>, Nadja Reinhardt<sup>2</sup>, Andras Sebok<sup>3</sup>, Susanne Braun<sup>2</sup>

<sup>1</sup> DISAFA, University of Turin, Italy;

<sup>2</sup> Center for Bioeconomy, University of Hohenheim, Germany;

<sup>3</sup> Campden BRI Hungary

\*sara.beduschi@unito.it, remigio.berruto@unito.it

---

### **ABSTRACT**

The bakery products subsector has the largest number of companies, value added, employees and number of companies in Europe (Food and Drinks, 2011). Over-consumption of energy in bakeries due to inefficient scheduling and production planning together with high shares of unsold bread waste (5-10% in Europe) is a big issue. Not only avoidable CO<sub>2</sub> emissions affecting climate change and society, but also excessive costs for SME bakeries are severe consequences. Recently, the EU has identified the bakery sector as one of the target sectors to apply best environmental practices. The aim of the envisaged project is in line with the goals of the EU (Regulation (EC) No 1221/2009, 2017/1508 of 28 August 2017 EU): minimising food waste and reducing energy consumption.

The Pro4Bake project aims to provide tools that could improve the bakery situation. A prospective production-planning tool for bakeries is being developed in this trans- and interdisciplinary project. Present machinery in bakeries is used to optimise the production process. The reduction of make span and idle time of machines, but also combinations thereof will lead to a higher economic and ecologic efficiency, thus, lower production costs for bakeries and lower climate change impact for society. The tool is developed using a flow-shop model, optimised by evolutionary algorithms, digital twins and artificial intelligence procedures. Adaptation to consumers' preferences will minimise food waste; hence, ecological footprint in bakeries, and lead to further optimisation of the baking process, product range and amount. Consumers' demands and expectations related to e.g. weather or holidays, and their acceptance of changes in product availability will play a significant role in the analysis. In the end, a computational application will help SME bakeries as users to adapt their production planning and processes to best practice. Subsequently, its potential in practical application will be examined and its impact broadened to the rest of Europe and beyond. Dissemination through technology transfer to users by involving professionals, students and learning videos will be performed. The product will be commercialised in the end to make it possible for bakeries to adapt to the truly needed amount and product range with optimised baking schedules to reduce energy consumption. The multidisciplinary approach, combining research optimisation methods and demand forecast approach used could be easily transferred to other agri-food sectors.

The project scope and aims, along with insight from the data collected in the first year, will be presented in this paper.

**Keywords:** bakery, food waste, sustainability, data collection, data analysis, process optimisation

---

## 1. Introduction

In response to the new challenges and opportunities for the food system today, EIT Food, the Europe's leading food innovation initiative, through the PrO4bake project, is working to make the bakery sector more sustainable.

## 2. Project description and aim

The PrO4bake project – Optimization of bakery processes by a computational tool together with consumer feedback to minimize ecological footprint and food waste will last until end of 2021. The PrO4Bake consortium involves the following partners: 4 universities (Turin, Aarhus, Lund, Hohenheim), 2 research centres (IARFR PAS, CSIC), 1 business partner (Siemens), 1 industry service provider (Campden BRI Hungary)

PrO4bake goal is to optimize the bakeries' production process by a computational tool. The reduction of make span and idle time of machines, but also combinations thereof will lead to a higher economic and ecologic efficiency, thus, lower production costs for bakeries and lower climate change impact for society. The production planning tool is developed using a flow-shop model, optimized by evolutionary algorithms, digital twins, and artificial intelligence procedures. Adaptation to consumers' preferences will minimize food waste, hence, ecological footprint in bakeries, and lead to further optimization of the baking process, product range, and amount. Consumers' demands and expectations related to e.g. weather or holidays, and their acceptance of changes in product availability will play a big role in the analysis.

In the end, a computational application will help SME bakeries as users to adapt their production planning and processes to best practices. Subsequently, its potential in practical application will be examined and its impact broadened to the rest of Europe and beyond. Dissemination through technology transfer to users by involving professionals, students, and learning videos will be performed. The product will be commercialized in the end to make it possible for bakeries to adapt to the truly needed amount and product range with optimized baking schedules to reduce energy consumption.

PrO4bake project takes an innovative approach to analyse the process data in the bakery sector. To achieve this goal, a strong base of data is needed to support the planning tool and demand prediction.

More information about the project could be found at (<https://www.eitfood.eu/projects/optimization-of-bakery-processes-by-a-computational-tool-together-with-consumer-feedback-to-minimize-ecological-footprint-and-food-waste-2020>)

## 3. Data collection in Italy – materials and methods

In order to provide a robust design for the computational tool, production data was collected in SMEs across Europe, at least three bakeries for each country participating in the project. The steps in Italy are described below and summarized in the following table:

- In an informative meeting in Turin at the local bakers association, the project was illustrated and the voluntary adhesions of three Piedmontese bakeries were collected (N 1).
- From September to November 2020, two data collections were conducted at 2 bakeries (N 2 and N 3). Due to the Covid-19 pandemic crisis, process data from the third bakery will be collected starting in April 2021.
- Preferences regarding consumption and motivation for purchase of bakery products in small independent artisan bakeries are explored with consumer questionnaires and focus group interviews (N 4 and N 5).
- A survey among the bakeries involved in the project on the requirements and needs of the sales forecasts generated by the new tool in the bakery sector (N 6)

N.	Country	Date	task
1	Italy	September 2020	Dissemination meeting – Associazione Panificatori Provincia Torino
2	Italy	October 2020	Data collection – bakery 1
3	Italy	October November 2020	Data collection – bakery 2
4	Italy	November 2020	On-line survey about consumption
5	Italy	December 2020	focus group about consumption
6	Italy	March 2021	On-line survey about forecasting requirements

Each of the SMEs recruited were small artisan bakeries (1 – 3 workers) selling their products directly to their customers. These bakeries made different types of bakery products by integrating the typical production of bread with other sweet products (cakes, biscuits, assorted pastries, traditional products...).

The production data collected include:

- Type of bakery product
- Utilized devices/machinery
- Energy consumption
- Number of operations/task
- Operation/task duration
- Weight of dough and items produced both raw and cooked
- Number of items produced
- Manpower used

The data was collected by dividing the production process of each baked product into individual stages as detailed as possible. Times were measured in minutes and seconds simultaneously by 2 specialized technicians from the University of Turin using digital stopwatches. The work is carried out mainly during the night shift.

The data collected will allow to compute duration and production cost for each bakery item made. Once the ingredients and selling price is known, it is possible to quantify the profit margin.

#### 4. Results



By way of example, we report some specific data referring to the first small artisan bakery participating in the project (bakery 1):


- 1 worker
- 1 electric oven
- daily production: about 15 different types of bread, 3 types of breadsticks, 7 types of focaccia and pizzas, and various pastries and cookies.


The table below shows the results of the data we elaborated on 4 bread items:

- the first three products (named ciabatta, ciabattina, zoccoletto) come from the same dough (dough type 4)
- the last one from a different dedicated dough (dough type 3).

To elaborate the results we considered the cost of electricity equal to 15 cents / kWh and the cost of labor equal to 15 euros / h. In addition, 84 working hours for 6 days a week.

PRODUCT NAME	RELATED DATA
<p><b>Ciabatta</b></p> 	<ul style="list-style-type: none"> <li>• Average weight: 510-540 [g]</li> <li>• Dough type: 4</li> <li>• # of operations/tasks to do: 12</li> <li>• Duration: 108,77 [min]</li> <li>• Energy consumption: 1,34 [kWh/kg]</li> <li>• Manpower: 1,40 [min/kg]</li> <li>• Energy cost: 0,20 [EUR/kg]</li> <li>• Manpower cost: 0,35 [EUR/kg]</li> <li>• Ingredients cost: 0,55 [EUR/kg]</li> <li>• Sales Price: 3,90 [EUR/kg]</li> <li>• Margin: 2,80 [EUR/kg]</li> </ul>
<p><b>Ciabattina</b></p> 	<ul style="list-style-type: none"> <li>• Average weight: 120-130 [g]</li> <li>• Dough type: 4</li> <li>• # of operations/tasks to do: 13</li> <li>• Duration: 98,86 [min]</li> <li>• Energy consumption: 1,10 [kWh/kg]</li> <li>• Manpower: 1,15 [min/kg]</li> <li>• Energy cost: 0,16 [EUR/kg]</li> <li>• Manpower cost: 0,29 [EUR/kg]</li> <li>• Ingredients cost: 0,55 [EUR/kg]</li> </ul>

	<ul style="list-style-type: none"> <li>• Sales Price: 3,90 [EUR/kg]</li> <li>• Margin: 2,90 [EUR/kg]</li> </ul>
<p><b>Zoccoletto</b></p> 	<ul style="list-style-type: none"> <li>• Average weight: 65-80 [g]</li> <li>• Dough type: 4</li> <li>• # of operations/tasks to do: 13</li> <li>• Duration: 85,26 [min]</li> <li>• Energy consumption: 1,72 [kWh/kg]</li> <li>• Manpower: 2,52 [min/kg]</li> <li>• Energy cost: 0,26 [EUR/kg]</li> <li>• Manpower cost: 0,63 [EUR/kg]</li> <li>• Ingredients cost: 0,55 [EUR/kg]</li> <li>• Sales Price: 3,90 [EUR/kg]</li> <li>• Margin: 2,46 [EUR/kg]</li> </ul>

PRODUCT NAME	RELATED DATA
<p><b>Barabriato</b></p> 	<ul style="list-style-type: none"> <li>• Average weight: 500-530 [g]</li> <li>• Dough type: 3</li> <li>• # of operations/tasks to do: 13</li> <li>• Duration: 161,50 [min]</li> <li>• Energy consumption: 3,58 [kWh/kg]</li> <li>• Manpower: 3,38 [min/kg]</li> <li>• Energy cost: 0,54 [EUR/kg]</li> <li>• Manpower cost: 0,84 [EUR/kg]</li> <li>• Ingredients cost: 0,60 [EUR/kg]</li> <li>• Sales Price: 3,90 [EUR/kg]</li> <li>• Margin: 1,92 [EUR/kg]</li> </ul>

## 5. Conclusions

From the data collected in the Italian small bakeries that joined the project, it emerged that:

- large loaves (of 500-700 g) are those produced in the most limited quantities because they meet the consumption needs of households made up of 3, 4, or more people. or consumption habits

linked to local tradition (older consumers who keep buying traditional local bread, albeit large, and consume it over several meals or several days, keeping it in the pantry).

- Having small bread that share the same dough could actually improve sustainability (less waste at
- in bakeries, the loaves that are made in greater quantities are small and single portions (about 50-100 g). This format reflects the reduction in the amount of bread consumed per meal by the Italian population and responds to the need to reduce food waste.
- the smaller sizes (about 40-50 g) are typically intended for restaurants, school canteens, catering ... where bread is an accessory element compared to the menu and is found alongside other types of bread products such as breadsticks, special breads, flatbreads ...
- in the bakeries where the surveys were carried out, the price of bread is the same for the different types and formats, except for special breads (rye, wholemeal, oats, cereals, etc.) and it is this aspect that the Pro4bake project would like to contribute to change: it would like to help enhance the different breads by obtaining a targeted economic feedback.
- it is interesting to note that the price is strongly influenced by the economic wealth of the area (neighboring areas produce different prices for bread) regardless of the local concentration of bakeries.
- unsold bread is generally reused in the following ways:
  1. is dried and ground to make breadcrumbs for cooking
  2. is sold for animal feed
  3. is given to family and friends
- the data collected are the basis for the creation of tools for the optimization of bakery processes and save energy consumed of the production devices and highlight that
  - the cooking times of the different types of bread are influenced by the size (larger items require longer times and more energy)
  - large doughs that originate different bread items allow optimizing the manpower in the preparation steps.

Adapting the produced amount and range of baked products to the demand of consumers as well as optimizing the bakery production processes and schedules is an essential part in making SME bakeries more competitive and sustainable.