**Sustainability, innovation and environmental impact of spray packaging   
applied to food and nutraceutical products: development of innovative sprayable solutions and study of their application in bakery and confectionery.**

Chiara Rossetti (chiara.rossetti1@unicatt.it)

DiSTAS – Department for Sustainable Food Process, Università Cattolica del Sacro Cuore, Cremona-Piacenza, Italy

Tutor: Prof. Roberta Dordoni; Co-tutor: Prof. Lorenzo Morelli

This PhD thesis research project is aimed at setting up an experimental procedure for the identification and the development of different formulations (such as mousses, fresh doughs, dressings, and nutraceuticals) that can be packaged in aerosol spray cans used in confectionery and bakery. They will be first produced through pilot plants, then rheologically and technologically characterized; the process will be finally validated in order to be applied on an industrial scale.

Sostenibilità, innovazione e gestione dell’impatto ambientale del confezionamento spray applicato ai prodotti alimentari e nutraceutici: sviluppo di soluzioni spray innovative e studio della loro applicazione per la produzione di prodotti da forno e prodotti dolciari.

Questo progetto di tesi di dottorato mira a mettere a punto un procedimento sperimentale per l’individuazione e lo sviluppo di diverse formulazioni (quali mousse, impasti freschi, preparazioni e prodotti nutraceutici) che possano essere confezionate in bombolette spray successivamente impiegate nelle filiere dei prodotti dolciari e da forno. Queste verranno prodotte attraverso impianti pilota, caratterizzate dal punto di vista reologico e tecnologico, e il processo verrà poi validato in modo da poter essere applicato anche su scala industriale.

# **1. State-of-the-Art**

Nowadays, industries of bakery and confectionery products are investing a lot in innovation and sustainability. This is mainly due to the new consumers’ request and to the focus on the reduction of transformation impact on the environment. For these reasons, the development of innovative and more sustainable products is fundamental both for academia and industry. Innovation in bakery and confectionery can be applied in different ways (Martínez-Monzó et al., 2013). Table 1 lists the latest innovations registered in the different fields of bakery and pastry.

***Table 1***Main innovations applied on bakery and confectionery (Martínez-Monzó et al., 2013).

|  |  |  |
| --- | --- | --- |
| **Drivers** | **Innovations applied** | **Examples of applications** |
| Health | Functional Ingredients | Probiotics or prebiotics addition |
|  | Energy & Satiety | Integration with fibers, antioxidants, vitamins, proteins |
|  | Gluten & Allergen free | Use of protein isolates, or fibers |
| Convenience | Smaller portions | Introduction of new formats (e.g. muffins) |
|  | Local and Seasonal | Regional and ethnic tastes |
| Pleasure | Specialties | Artisan products |
|  | Fashion flavors | Salty/sweet, sweet/spicy |

The reformulation and the provision of an added-value to a product can be very useful when innovating it; but the packaging also represent an important factor that can be considered. Today’s consumers are aware of environmental sustainability and the choice of the correct type of packaging is critical in trying to make it more sustainable by maintaining its preservatives properties (Mitelut et al., 2021).

For these reasons, I would like to focus my doctoral project on the development of some innovative and added-value recipes that can be applied in bakery and confectionery investigating also the possibility of using a new type of pack: a sprayable can, in order to create an easy use product with an easy storage (already used for whipped cream and drugs). Aerosol products represents a good packaging solution: they are versatile, easy to use, clean and efficient; moreover, they are made of completely recyclable material, they can guarantee longer storage times without the use of cold chain, they can reduce the chances of contaminations, and they contribute to waste reduction (for no unused product to be disposed of).

The initial approach of this research project will involve the application of this new packaging technique to some enriched food preparations (such as glazers or mousses) and, only later, focus the attention on cake batters (due to the fact that sponge cakes are the most popular and consumed within baked goods) (Rodríguez-García et al., 2013). This kind of samples could also have an easy application to a sprayable packaging, giving them more stability and an easier way to use. This packaging solution has already been studied for pancakes using a siphon loaded with pressurized gas (Lostie et al., 2002), so it might be easily adapted to a different type of batter (Principato et al., 2021). The samples will be analysed in order to define their microbiological and physical stability, also considering their rheological behaviour; a shelf-life study should be also conducted to understand the stability in the long term and the effect of the packaging on the samples.

# **2. PhD Thesis Objectives and Milestones**

Within the overall objective mentioned above this PhD thesis project can be subdivided into the following activities according to the Gantt diagram given in Table 2:

A1) **Research:** a deeper research focused on both the scientific results reached until now regarding bakery, confectionary, spray gases, and technique (A1.1); associated with a market research in order to understand what are the products already present on the market and what can be developed as an alternative (A1.2).

A2) **Semi-finished sprayable base preparations used in bakery and confectionery:** some base preparations already used in bakery and confectionery will be characterized and specifically modified in their composition in order to make them sprayable. The samples will be evaluated to understand their microbiological stability and safety (A2.1); and characterized in terms of rheology to have more information about their structure (A2.2). Formulations will be also subjected to a shelf-life study (A2.3), and finally some trials will be done applying them on some bakery goods (A2.4) in order to evaluate if the sprayable form can be comparable to the traditional one (from the technological and sensory point of view).

A3) **Development of a completely new sprayable product:** use of a pilot plant for the development of different kind of mousses and cake batters that will be packed into a sprayable can, also integrated with nutraceutical and functional compounds (A3.1). The samples will be first monitored to guarantee their microbiological stability (A3.2), and then analysed from the rheology point of view to obtain information related to their viscosity and stability (A3.3). A shelf-life study will be conducted to verify their long-term stability (A3.4). Finally, the final obtained product (the mousse or the baked cake) will be physically and sensory characterized (A3.5).

A4) **Scaling up at an industrial level:** once defined the most performing preparations and sprayable products, their formulations will be optimized in order to standardize the process in a pilot plant scale (A4.1); then, they will be scaled up at an industrial level with the contribution of a Company specialized in aerosol products production (A4.2).

A5) **Writing and Editing** of the PhD thesis, scientific papers, and oral and/or poster communications.

***Table 2***Gantt diagram for this PhD thesis project.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Months Activity | | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** | **26** | **28** | **30** | **32** | **34** | **36** |
| A1) | ***Research*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Bibliographic scientific research |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Market research |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Semi-finished sprayable base preparations*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Microbial stability |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Rheological stability |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3) Shelf-life study |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 4) Application on finished products |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A3) | ***Development of a completely new sprayable product*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Pilot plant production |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Microbial stability |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3) Rheological stability |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 4) Shelf-life study |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5) Technological characterization of the obtained final product |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A4) | ***Scaling up at an industrial level*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Optimal Process |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Scale up |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Thesis and Paper Preparation*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

# **3. Selected References**

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