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# Optimization of microwave cooking of beef burgundy in terms of nutritional and organoleptic properties

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ABSTRACT

The premise was to adapt a conventional beef burgundy model for use in microwave cooking (MC) whilst preserving nutritional and eating qualities. The effects of specific power and different cooking times were measured by meat tenderness, Nε-carboxymethyllysine (CML), lysine, polyphenol contents and energy consumption. A CORICO (CORrelations ICOnography) design for four factors (specific power, times of browning, cooking and reduction) was used to compare MC and traditional cooking (TC) determining the optimized MC conditions. For the optimal conditions (specific power of 0.84 W/g and a cooking time of 84 min), the level of CML product was similar to that measured after TC. However, lysine degradation was more pronounced when TC was used compared to optimized MC. Consumer tests showed that the eating quality of the beef burgundy cooked using MC compared favourably to that of the TC. Energy consumption of the optimized MC conditions was lower than the conventional process (4.67 kWh vs 6.52 kWh) and the cooking time was decreased by 56% compared to TC.

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## 1. Introduction

Cooking is the art and science of preparing food for consumption generally by the application of a heat treatment. The aim being to develop the organoleptic properties, nutritional characteristics and to ensure good food safety practices. There is an increasing interest in microwaving foods for several reasons: it is faster than conventional methods, the energy consumption is often lower and foods cooked by microwaving maintain nutritional integrity (Akkarachaneeyakorn et al., 2010; Domiszewski, Bienkiewicz, & Plust, 2011; Kala & Prakash, 2006).

The food industry uses microwave technology for processes such as drying, blanching, pasteurization and cooking (Chandrasekaran, Ramanathan, & Basak, 2013). In contrast, the catering industry uses microwave ovens mainly for reheating pre-prepared products. This limited use is largely due to the lack of experimentation, training, understanding and application of the potential benefits of the microwaving. In the absence of basic or fundamental procedures for even traditional recipes, the technology remains underutilized. However, it is important to mention some drawbacks occurring during microwave cooking like non-uniformity of heating, lack of browning and undesired textural changes (İçöz, Sumnu, & Sahin, 2004; Mizrahi, 2012; Uzzan, Kesselman, Ramon, Kopelman, & Mizrahi, 2006). These drawbacks are due to uneven temperatures occurring during microwave heating and can affect the eating quality (Yarmand & Homayouni, 2009).

Another aspect of the cooking of food is the development of the nutritional characteristics of the products. During the heat treatment of some food, Maillard reaction products (MRPs) are formed between reducing sugars and amino acids. MRPs are mainly involved in the browning of foods and have a positive effect on flavour characteristics. However, some potentially harmful advanced glycation end-products (AGEs) resulting from the Maillard reaction have been found to accumulate in food during processing and storage (Henle, 2003). Among them, $N^{\varepsilon}$-carboxymethyl-lysine (CML) is frequently measured in foods as a

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marker of the presence of AGEs. Some studies show that microwave heating could promote the CML formation compared to conventional heating (Fu, Li, & Li, 2012; Li et al., 2012). Another study of infant formula had different findings and showed that high specific power for a short time could minimize the CML formation during microwave treatment (Laguerre et al., 2011).

Another effect on MRPs is the irreversible chemical modification of some targeted amino acids and the reduction of the nutritional quality of proteins. The most affected amino acid is lysine, which is an essential amino acids that reacts easily with reducing sugars and becomes unavailable (Tessier & Niquet, 2007). The analyses of simple model systems based on the incubation of proteins with carbohydrates indicated that the loss of lysine can be up to 54% when the incubation is at 95 °C for up to 8 h (Lima, Assar, & Ames, 2010). Different heat treatments such as microwave heating were also compared, to evaluate their influence on the loss of lysine and formation of CML. In this study, the loss of lysine was found to be high when microwave technology was used (Fu et al., 2012).

Besides the modifications due to the Maillard reaction many other changes in chemical composition can occur. Phenolic compounds found mainly in vegetables but also in wine are susceptible to heat damage when cooked. Cooking can also be associated with a reduction or elimination of the microbial loads (Ball & Olson, 1957, 654pp.; Pittia, Furlanetto, Maifreni, Tassan Mangina, & Dalla Rosa, 2008). For,conventional cooking of ready-made meal, the authorities recommend to maintain a core temperature of 70 °C for 38 min during cooking to achieve a 12-13 log reduction of *Enterococcus faecalis* as target germ (Martin, 1984; Stumbo, 2006, 329 pp.). Due to non-uniform temperature distribution, some regions of the material get heated very rapidly (hotspots), while others receive heat to a lesser extent (cold spots) (Chandrasekaran et al., 2013). Thus, microbial analysis must be done to prove that pathogenic microorganisms are killed during microwave heating (Laguerre et al., 2011; Tessier, Gadonna-Widehem, & Laguerre, 2006).

The prolonged cooking time of slowly cooking meat became unfashionable and overlooked. However, this practice allows the use of cheap cuts, while enhancing the nutritious and organoleptic properties of the dish. This study looked at a slow-cooked dish made up predominantly of meat: that of the beef burgundy. In this traditional French recipe, the method of slowly simmering the beef in wine makes the meat tender and improved organoleptic acceptance.

The aim of this study was to adapt beef burgundy as a slow-cooked beef stew model for use in microwave cooking (MC) while preserving nutritional and eating quality of the dish. Optimization of MC conditions was performed using CORICO method (Correlation of Iconography) based on partial and total correlation calculations. A consumer test and a microbial counting were carried out to validate these optimized conditions in terms of overall acceptability and sanitary quality.

## 2. Materials and methods

### 2.1. Beef burgundy cooking

#### 2.1.1. Ingredients

The ingredients were purchased at a local foodservice supplier (Promocash, France). Smoked bacon was used along with fresh garlic, onions, frozen carrots, mushrooms, wine vinegar, red wine (Pinot noir), beef stock, bay leaves, thyme and whole black peppercorns.

The meat (brisket) was cut into pieces of 6 cm long, 3 cm wide and 2 cm thick and frozen to (−18 °C) for 24 h prior to use to improve tenderness.

#### 2.1.2. Cooking steps

The beef burgundy was prepared in three steps called browning, cooking and reduction.

- Browning

The meat, carrots, bacon cubes, onions and wine vinegar were mixed together. This step sealed the meat and limited moisture loss.

- Cooking
- Red wine, beef stock, garlic, herbs and spices were added. Reduction

Mushrooms and onions were added to thicken the sauce. At the end of the reduction, the dish was cooled down at room temperature to perform the physicochemical analysis (Fig. 1).

#### 2.1.3. Cooking methods

Microwave cooking (MC) and traditional cooking (TC) used as reference were carried out by using the Air-o-Speed oven adapted for catering, (Electrolux AOW101EA, Italy). This oven combines several heat technologies: convective hot air, steam and microwave (2450 MHz).

For the TC the convective mode of oven was used. The dish was prepared in a stainless steel container (5.3 L). TC consisted in browning the meat for 10 min at 220 °C (uncovered), cooking for 90 min at 150 °C (covered) and reducing (uncovered) at 150 °C for 60 min and covered at 150 °C during 30 min. The whole cooking time was 3 h 10.

For the MC only the microwave mode of the oven was selected. The dish was prepared in a polypropylene container (5.3 L). Five power levels were set (1000, 1500, 2000, 2500 and 3000 W) which correspond to different specific power levels with sample weight varying between 1667 and 2727 g. For each setting, corresponding

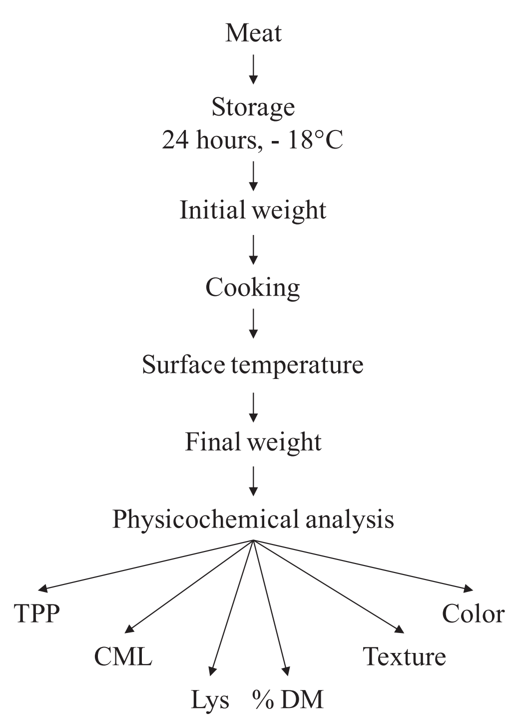


**Fig. 1.** Overview of the procedure. Abbreviations: DM = dry matter content, CML = carboxymethyllysine, Lys = lysine content, TPP = total polyphenol content.

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