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Advantages of sous-vide cooked red cabbage: Structural, nutritional and sensory aspects

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ABSTRACT

The comparison between equivalent cooking treatments should be applied in a systematic way. This study proposes a methodical way to provide cooked samples with similar firmness using two cooking treatments. In addition, the structural, nutritional and sensory properties of red cabbage cooked with sous-vide treatment in comparison with traditional cooking (boiling water) was evaluated. Changes in texture, color and anthocyanin content were measured in samples cooked with traditional cooking (for different times) and sous-vide (modifying time and temperature according to a Response Surface Methodology). Consumers described sensory properties and preferences between samples. Cryo-scanning electron microscopy was used to study the samples microstructure.

The firmness of samples, traditionally cooked for 11 min and preferred by consumers, was achieved in samples cooked with sous-vide treatment by optimizing of the cooking conditions (87 °C/50 min or 91 °C/30 min). Sous-vide treatment was preferred to traditional cooking by consumers. Sous-vide samples were more purple, more aromatic and tastier than traditionally cooked ones. The loss of anthocyanins in traditional cooking was twice that in sous-vide samples. Micrographs from different treatments showed different degrees of cell wall damage. Sous-vide treatment could be recommended as a treatment for the catering industry providing better quality products.

1. Introduction

The incorporation of red cabbage (*Brassica oleracea* convar. capitata var. capitata f. rubra) in the diet is beneficial to the consumer because of its high-water, fiber and antioxidant content, such as anthocyanins (Duyn et al., 2000; Halvorsen et al., 2002).

The red cabbage is traditionally cooked in boiling water (around 100 °C according to the atmospheric pressure) for several minutes. This habitual treatment is drastic as it applies high temperatures. Therefore, the beneficial compounds, such as anthocyanins, could be destroyed by heat.

Considering other cooking methods, sous-vide treatment is based on raw materials or raw materials with intermediate foods that are cooked under controlled conditions of temperature and time inside heat-stable vacuum pouches (Baldwin, 2012; Schellekens, 1996). The use of sous-vide was widely applied in restaurants and caterings. To assure the microbial safety during its use despite the risk related to the use of low temperatures, practical manuals for its use were published (Baldwin & Nutridox, 2010; Ghazala, 1998; Gould, 1999; Light & Walker, 1990). The sous-vide method has now become a popular and safe treatment used in the catering industry (Dodgshun, Peters, & O'Dea, 2011).

The nutritional benefits of sous-vide have been studied (Chiavaro et al., 2012; Petersen, 1993; Trejo-Araya et al., 2009). In cooking treatments, time and temperature are the main factors. Kinetic models (considered primary models) characterize the changes (such as firmness and color) according to time. In environmental conditions, other factors such as temperature are commonly modeled using a secondary model. Primary and secondary models could be combined in differential equations permitting the description of a process under dynamic conditions. Experimental design, such as response surface methodology (RSM) could be also useful for modeling. RSM has been developed to explore relationships between several variables and one or more responses. This permits selection of an adequate combination of conditions to achieve an optimal or desired response (Box & Hunter, 1957).

Sensory evaluation is important for developing products, but the cost of the study and the quantity of products used mean that the process has to be as efficient as possible. The use of instrumental

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texture measurements, such as the Kramer cell test, puncture test and Warner Bratzler test (McKenna & Kilcast, 2004), have been shown to correlate with sensory evaluation (Bourne, 2002). Therefore, they can replace sensory tests for assessing products in the first steps of development new products (Meullenet, Lyon, Carpenter, & Lyon, 1998; Walter, Truong, & Espinel, 2002).

Sensory quality is one of the prime concerns in the catering industry which applies the sous-vide to minimize the workload during services and to produce dishes using second-class cuts of meat and poultry with extraordinary tenderness and texture (Dodgshun et al., 2011). Therefore, it is important to understand how cooking techniques, cooking time and temperature affect the sensory quality. Different tests have been applied to discern the opinion and the perceptions of the consumers, such as JAR (Just About Right) scale and FP (Flash Profiling). The JAR (Just About Right) scale permits the measurement of the intensity of specific attributes linked to hedonic assessment by consumers (Gacula, Rutenbeck, Pollack, Resurreccion, & Moskowitz, 2007), while FP facilitates sensorial descriptions by reducing the training time of assessors (Dairou & Sieffermann, 2002).

With the aim to find equivalent cooking conditions providing a similar firmness between two treatments reducing as much as possible the number of sensory tests, the present study proposes a methodical way based on the Response Surface Methodology combining instrumental and sensory analysis. In addition, the study evaluated the structural, nutritional and sensory features of red cabbage cooked with sous-vide treatment and traditional cooking.

2. Materials and methods

2.1. Materials

Red cabbage (*B. oleracea* convar. capitata var. capitata f. rubra) purchased from a local company (Reypama, Spain) was used for the tests. Samples were harvested a week before the experiments and stored at 4 °C until their use. The leaves were washed and cut into discs (20 mm diameter) using a manual cylinder cutter.

2.2. Cooking methods

Two cooking methods were applied: the traditional cooking (with time modifiable and temperature around 100 °C -boiling water at atmospheric pressure-) and the sous-vide treatment (with modifiable time and temperature).

Traditional cooking was carried out using a stainless steel saucepan for times of 30 s (blanching), 7 min, 11 min or 15 min with a constant product weight:water volume ratio of 1:40. After the cooking treatment, all samples were rapidly cooled in a water-ice bath for a minute as usually doing by professional cooks, and then vacuum packaged in pouches (Cryovac® HT3050) applying vacuum conditions (98% vacuum) with a vacuum packaging machine (EV-25, Technotrip, Spain). The pouches were stored at low temperature at 3–4 °C for 24 h, before the instrumental measurements to simulate conditions in the catering industry.

For the sous-vide treatment, the raw red cabbage discs were vacuum sealed in thermoresistant pouches (Cryovac® HT3050) applying vacuum conditions (98% vacuum) with a vacuum packaging machine (EV-25, Technotrip, Spain). The heat treatment was conducted in a water bath cooker (GD 120, Grant Instruments, Cambridge, UK) at atmospheric pressure. Table 1 shows the time and temperature of the cooking conditions. After the cooking treatment, all pouches containing sous-vide samples were rapidly cooled in a water-ice bath for a minute as usually doing by professional cooks. The pouches were stored at low temperature at 3–4 °C for 24 h, before the instrumental measurements to simulate conditions in the catering industry.

Table 1
Second-order design matrix used to evaluate the effects of temperature (T) and time (t) on the texture and color of red cabbage.

RUNS	Independent variables			
	Coded levels		Originals levels	
	T (°C)	t (min)	T (°C)	t (min)
1	−1	−1	80	30
2	1	−1	90	30
3	−1	1	80	50
4	1	1	90	50
5	−1.414	0	77.9	40
6	1.414	0	92.1	40
7	0	−1.414	85	25.9
8	0	1.414	85	54.1
9	0	0	85	40
10	0	0	85	40
11	0	0	85	40
12	0	0	85	40
13	0	0	85	40
14	0	0	85	40
15	0	0	85	40
16	0	0	85	40

2.3. Sensory analyses

A just about right (JAR) test was used to evaluate firmness of samples cooked with traditional cooking (100 °C) at three different times (7 min, 11 min and 15 min). Consumers ($n = 65$) evaluated the firmness of cooked red cabbage using a 5-point just about right (JAR) scale (1 = too soft, 3 = just about right; 5 = too hard) (Gacula et al., 2007).

Paired tests were carried out following ISO standards (ISO, 2005). Two paired test were used in this study. The first one was used to analyze the perceptive differences between sous-vide samples cooked with two different combinations of factors (time and temperature). In this test consumers ($n = 47$) were questioned about firmness, purple color, aroma, taste and preference.

The second one was carried out to compare treatments (sous-vide and traditional cooking). The purpose was to discern the preference and differences perceived in attributes (firmness, purple color, aroma and taste) by consumers ($n = 92$). Also questions related to global preference and the most important attribute for the choice of preferred sample were added.

Flash profiling (FP) was used to obtain information about characteristics perceived by consumers related to different cooking treatments and cooking conditions (Dairou & Sieffermann, 2002). FP was used to describe the samples cooked by five treatments based on traditional cooking (7 min, 11 min and 15 min) and sous-vide (87 °C/50 min and 91 °C/30 min). Consumers received 6 samples at the same time, of which two samples were from the same treatment to validate the study (91 °C/30 min) and check the performance of consumers according to a cluster test applied to the coordinates for each samples provided by the Generalized Procrustes Analysis (GPA). 28 non-trained consumers participated in the test and the performance to describe the intensity of attributes was verified. After applied the Generalized Procrustes Analysis, the coordinates of the position of each samples according to the perceptions of each consumers has been obtained. To each consumer, the coordinates has been analysed with a cluster analysis. 10 consumers have been ruling out due to the lack of consistency in his criteria because the samples from the same treatment were not