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Effects of different cooking methods on the chemical and physical properties of carrots and green peas

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A R T I C L E I N F O

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A B S T R A C T

The study was aimed to evaluate the physicochemical effects of three cooking methods i.e. sous-vide (SV), cook-vide (CV) and traditional cooking (TC) on carrots and green peas. SV and CV were performed at 60–90 °C for various time periods (SV: green peas 50–100 min, carrots 90–150 min; CV: green peas 30–70 min, carrots 20–60 min) with respect to peroxidase test. These vegetables were also cooked at atmospheric pressure for 15, 30, 45 and 60 min and the results were compared with those obtained from SV and CV. Antioxidant activity, total phenolic and vitamin C analyses reflected less harm to the green peas in CV as compared to SV and TC. However, carrots were approximately half degraded during SV than in CV and TC as shown by the antioxidant activity. Moreover, total phenolic content of carrots was highly protected when cooked in SV method. The color change values (ΔE) of green peas were slightly lower in TC when compared to CV and SV, while in carrots, they were very close to each other's in all three methods. CV-cooked green peas and carrots provided the highest general acceptance for the sensorial properties. As a conclusion, TC had more adverse effects on the quality characteristics on green peas and carrots.

1. Introduction

In recent years, the awareness to consume more healthy food is on the rise. As a rich source of proteins and vitamins, more vegetables are grown and eaten. Green peas and carrots are most popular vegetables in the world (Martín Cerdeño, 2009). Green peas are rich in proteins, complex carbohydrates, dietary fibers, minerals, vitamins and antioxidants (Urbano et al., 2005). Carrots are also rich in cellulose, sugars, proteins and other bioactive compounds (Gong, Deng, Han, & Ning, 2015). Although carrots can be consumed uncooked, they are, as well as green peas, generally cooked before the consumption.

Cooking process leads to change in the chemical composition and physical structure of foods (Zhang & Hamauzu, 2004). These changes depend on cooking temperature, pressure and time. Cooking method is generally selected according to the nutritional value, sensorial characteristics of the final product, energy and time consumption etc. (Baysal, 1986; Sağun, Testereci, Yörük, & Ekici, 1997). Cooking may lead to minerals and vitamins loss and changes in fatty acid composition depending on the lipid oxidation (Rodriguez-Estrada, Penazzi, Caboni, Bertacco, & Lercker, 1997). In the traditional cooking (TC), vegetables are mostly immersed in boiling water (~100 °C) at atmospheric conditions for several minutes (Araya et al., 2009), however, it results in loss of flavor, color and vitamins (Somsub, Kongkachuichai, Sungpuag, & Charoensiri, 2008) due to the high boiling temperature. Thus, alternative methods have been tried to develop to cook foods at lower temperatures and shorter times (Iborra-Bernad, Philippon, García-Segovia, & Martínez-Monzó, 2013) e.g. microwave, radio-waves, ohmic, vacuum treatments, and high-pressure (Cheng & Sun, 2008).

The vacuum cooking method has become popular over the last decades. Sous-vide (SV) and cook-vide (CV) are popular vacuum treatments in food technology. Vacuum cooking is superior to TC due to the lack of oxygen in cooking environment and working at low temperature. Low temperature cooking results higher flavor retention, lower acrylamide formation and higher capacity of pigment retention (Iborra-Bernad, Tárrega, García-Segovia, & Martínez-Monzó, 2014).

SV cooking is characterized as: “raw materials or raw materials with intermediate foods that are cooked under the controlled conditions of temperature and time inside the heat-stable vacuumed pouches or container” (Baldwin, 2012). This method provides unique textural characteristics, lower moisture loss, less lipid oxidation resulted from

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the absence of oxygen in pouch, modifications of profile of volatile flavor compounds and different color characteristics (Oz & Seyyar, 2016). Besides, food in pouch can be consumed directly after short heating step. Thus, SV helps the catering sector as well (Dogruyol & Mol, 2016). Food material in pouch could be stored for a long time without losing freshness of food and delivered to the consumer with high quality (Creed & Reeve, 1998). SV also improves the microbial quality and the shelf-life of the food products (Armstrong & McIlveen, 2000).

The other alternative method for cooking of foods under vacuum conditions is CV which is known as a remarkable cooking method due to its low-temperature application, short processing time, oxygen-reduced cooking environment and the better protection of nutritional value and the physical structure of foods (Andrés-Bello, García-Segovia, & Martínez-Monzó, 2009). CV provides minimum losses of nutritional value of foods and minimum formation of carcinogenic compounds (HMF, acrylamide) (Martínez-Hernández et al., 2013), achieves better texture, color and flavor (García-Segovia, Andrés-Bello, & Martínez-Monzó, 2008) and also better sensory quality (Martínez-Hernández et al., 2013). Heat is transferred by conduction and convection in CV and in SV (De Baerdemaeker & Nicolaï, 1995). In CV, water boils at low temperature to less vapor pressure (Mir-Bel, Oria, & Salvador, 2012). However in SV, water in cooking chamber does not boil because of low temperature at atmospheric condition. While food samples are contact with water at boiling temperature in CV, food samples do not contact water directly in SV due to the wrapping a packing material. Moreover, at the same temperature, the surface heat transfer coefficient is higher in boiling water (CV) than in liquid water (SV) (Iborra-Bernad et al., 2013). Thus, heat transfer in SV is slower than in CV.

Iborra-Bernad et al. (2014) investigated the effect of different cooking methods on textural and sensory properties of carrots. They found that the traditional cooked carrots got higher firmness value as compared to the vacuum cooked ones. Iborra-Bernad et al. (2013) also compared SV and CV methods for green bean pods. Green beans cooked with CV had higher greenness value compared to SV, while flavor and overall preference of green beans cooked with SV had higher scores.

This study was aimed to investigate the physical and chemical effects of three different cooking methods i.e. sous-vide (SV), cook-vide (CV) and traditional cooking (TC) on carrots and green peas. These three cooking methods were also compared in terms of cooking time of the selected two vegetables after cooking processes.

2. Materials and methods

2.1. Materials

Commercially frozen packed green peas (*Pisum sativum*) were purchased from a local market in Izmir. Frozen green peas were used as they are available in this form in the local markets in Turkey. Carrots (*Daucus carota sativus*) are preferred as fresh. Carrots and green peas were stored at 4 °C and at − 18 °C, respectively. No pretreatment was applied to the frozen green peas, however, carrots were washed, peeled and cubed (1 × 1 × 1 cm) before cooking. Hence each carrot cube had nearly equal ratio of xylem and phloem parts. For sous-vide treatments, carrot cubes and frozen green peas were sealed under the vacuum in heat resistant laminated pouches (25% polyamide, 75% polypropylene, thickness: 95 μm) where the vacuum level was 93% (atm).

2.2. Cooking methods

Green peas and carrots were cooked using three different methods i.e. cook-vide (CV), sous-vide (SV), and traditional cooking (TC). Temperature and time were selected as independent process variables in central composite rotatable design (CCRD). The ranges of cooking time in SV and CV methods were determined with respect to peroxidase test at 75 °C per each 5 min. This test was used to determine the degree of blanching process, because it is known as the most heat stable enzyme in vegetables (Préstamo, Palomares, & Sanz, 2004). Peroxidase was inactivated at 75 °C as follows: green peas; 75 min in SV and 50 min in CV, carrots: 120 min in SV and 40 min in CV. The centre points of experimental design were selected by considering of these peroxidase inactivation points in SV and CV. The minimum applied temperature was 60 °C to reduce cooking time, while the maximum temperature was 90 °C that is very near to the temperature of traditional cooking. Cooking times were selected considering the effect of SV and CV processes on physical and chemical properties of green peas and carrot.

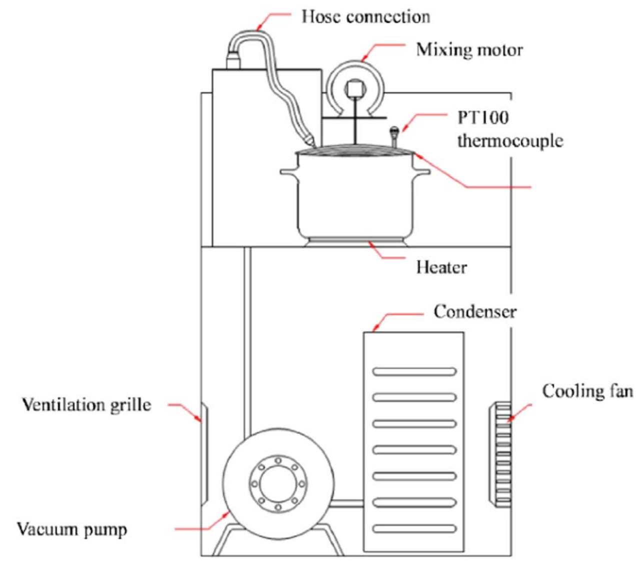

Fig. 1. Vacuum cooking equipment prototype.

A 6-liter prototype vacuum cooker was designed that was capable to work at various precise vacuum and temperatures. The vacuum cooker consists of an electrical heater (1.5 kW), an oil-based vacuum pump (0.55 hp) and a condenser (1 kW) worked with R-404a refrigerant (Fig. 1). A temperature probe (PT 100) was also adapted to the cooker to measure the internal temperature of the vessel. Applied vacuum level was measured from inside of the cooker. While vacuum level and cooking time were controlled by PLC system, electrical heater was programmed with PID control system. The internal temperature of the cooker, vapor temperature at the condenser's exit and internal pressure of cooker were recorded per each 3 s. Carrots and green peas were cooked at different temperatures and times under CV method to understand the effect of the process conditions on cooking quality. The vacuum pressure inside the cooker was applied according to the vapor pressure of water for each cooking temperature, therefore absolute pressure was varied in the range of 20 to 70 kPa (for CV, absolute pressure was 20, 25, 40, 60, 70 kPa at 60, 64.39, 75, 85.61 and 90 °C, respectively). The process conditions of CV method were arranged according to CCRD experimental design as shown in Tables 2 and 4.

For SV method, the green peas and carrot dices were hermetically vacuum wrapped and cooked in a water bath (Wisd Refrigerated Bath Circulator Model: WCR-P8) at different time-temperature conditions according to CCRD experimental design as given in Tables 1 and 3. After cooking, the samples were cooled rapidly in a chiller (PolyScience Model: 9602) at 4 °C for 30 min and stored at refrigerated conditions for further analysis.

In TC, green peas and carrot dices were cooked at 100 °C for 15, 30, 45 and 60 min in the same cooker without vacuum pump function. All cooking experiments were performed in replicate for each operating condition, besides each analysis in thrice.