Effects of Dense Phase Carbon Dioxide Treatments on Qualities of Fresh-cut Bitter Gourd

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Abstract. The effect of the dense phase carbon dioxide (DPCD), sodium hypochlorite and blanching treatments on qualities of the fresh-cut bitter gourd was compared. The DPCD treatment reduced the total bacterial count effectively, and the increasing processing time lead to a better effect of sterilization. Meanwhile, the DPCD treatment showed no influence on the total soluble solid content of the fresh-cut bitter gourd. However, the DPCD treatment reduced the ascorbic acid content and pH value of the fresh-cut bitter gourd.

Introduction  
Bitter gourd has shown the healthcare function, including the detoxification, lowering blood sugar and blood fat, antibacterial and antitumor [1,2]. Fresh-cut bitter gourds are prepared to meet the requirement of the ready-to-eat or ready-to-use product. Pasteurization is a key part for the preparation the fresh-cut bitter gourd [3]. Sodium hypochlorite has been widely used to reduce the total microflora counts [4]. But the residual of the sodium hypochlorite treatment has draw more and more attention of the consumers. The heat blanching has been successfully to reduce the total microflora counts of fresh-cut fruits as the sodium hypochlorite treatment. However, the heat blanching treatment usually accelerates the browning of the fruits and vegetables as well [5, 6].

Dense phase carbon dioxide (DPCD) is a non-thermal pasteurization that affects microorganisms, enzymes and the structure of cells through molecular effects of CO\textsubscript{2} [7]. The DPCD process has been applied to many different fields of food processing [8]. The DPCD treatment has contribute to a better bactericidal efficiency of fresh-cut carrot [9], cocoyam, and sweet potato[10]. However, there are almost obscure and scarcely studies about the information of the inactivation mechanism of the DPCD treatment which was used for fresh-cut bitter gourd [11].

Hence, the effect of treat time of the DPCD treatment on qualities of the fresh-cut bitter gourds was evaluated with the sodium hypochlorite and blanching treatments as a control.
Materials and Methods

Preparation of Fresh-cut Bitter Gourd

Bitter gourds were from a local fruit and vegetable market in Haidian District, Beijing, China. The gourd was stored as at 4 °C for 24 h. And then the fruits were washed by the running tap water to remove the surface contamination, and stirred at 800 rpm for 10 min. The drained fruits were sliced to 4 mm thickness and removed the seeds. And then the cut fruits were subjected to the heat blanching, Sodium hypochlorite, and DPCD treatment respectively.

Control. The cut fruits were nominated as the control.

Blanching Treatment. The fruits were heated as 52 °C for 2 min in a water bath (Stable Temp Co., Ltd., Cole-Parmer, USA). And then the fruits were cooled to 4 °C in icy water.

Sodium Hypochlorite Treatment. The fruits were immersed in a 100 ppm solution of sodium hypochlorite for 2 min and then rinsed with icy water to reach the temperature of 4 °C. And then the fruits were centrifuged at 800 rpm for 10 min to remove excess water.

DPCD Treatment. The discontinuous DPCD treatment apparatus was manufactured by Haian Co. Ltd., China. The system consisted of a 1 L stainless steel pressure vessel, temperature controllers, pressure gages and two plunger-type pumps. The system pressure was controlled by a back-pressure regulator and indicated by pointer manometers. An electrical heating jacket was placed around the vessel. Another thermocouple, connected to a temperature controller, was to control and maintain a constant temperature [10]. The pressure and temperature were controlled to an accuracy of ± 0.4 MPa and ± 0.5 °C, respectively. The fruits was subjected the DPCD treatment of 6 MPa for 2 and 10 min respectively. The temperature of the pressure vessel was hold in 25 °C with an accuracy of ± 0.5 °C during the whole process. Depressurization of CO₂ occurred in less than 10 min [12].

After the blanching, Sodium hypochlorite, and DPCD treatments, the fruit was packaged for every 200 g in polyethylene films.

Total Microflora Counts

Samples were serially diluted, plated in total count agar for total microflora counts, followed the recently reported method [13]. The plates were incubated at 37 °C for 48 h and counted manually.

Determination of Ascorbic Acid Content

The ascorbic acid was determined by ultraviolet spectrophotometer (UV-1800, Shimadzu, Tokyo, Japan). 50 g of bitter gourd sample was homogenized with 50 ml of oxalic acid-EDTA solution (oxalic acid 0.05 mol/L, EDTA 0.2 mol/L) using the homogenizer (HR1364 Philips electronics, Co., Ltd., Hong Kong). Then the homogenate was stored at 4 °C for 10 min and afterwards filtered through 4 × folded gauze. The filtrate was centrifuged for 15 min at 3000 rpm, and 2 ml of the supernatant was added in 0.5 ml partial chloroacetic acid, 1 ml 0.5 % sulfuric acid and 2 ml 50 g/L ammonium molybdate solution then homogeneous mixed, put the mixture in a dark place for 15 min. The absorbance value was measured at 590 nm. All the experiments were performed in triplicates. The ascorbic acid content was calculated using the modified Li Jun [14] formula shown in Eq.(1):

\[
Vc (mg / g) = \frac{C \times V1}{W \times V2}
\]  

(1)

Where C is the content of ascorbic acid, V1 is the volume of sample solution, V2 is total volume of the constant volume, W is the weight of samples.
**Total Soluble Solid and pH Determination**

The total soluble solid of the fruits was measured in triplicate at 25 °C using a digital refractometer PAL-1 (Atago Ltd., Japan).

The fruits of about 30 g was homogenized and the pH was measured using a digital pH meter (Seven Compact Ltd., Shanghai, China), after calibration with commercial buffer solutions at pH 7.0 and 4.0.

**Statistical Analysis**

Analysis of variance (ANOVA) was used to compare mean differences of the results. If the differences in mean existed, multiple comparisons were performed using Duncan’s Multiple Range Test. All analysis was conducted using SPSS for Window Version 19. All experiments were done in triplicates or more.

**Results and Discussion**

**Effect of DPCD Treatments on Total Bacterial Count of Fresh-cut Bitter Gourd**

Our preliminary experiments showed that the excessive pressure destroyed the appearance of fresh-cut bitter gourd. Hence, the pressure of 6 MPa was applied in the DPCD treatment. Fig. 1 presents the effect of DPCD treatments on total bacterial count of fresh-cut bitter gourd. The DPCD treatment for 2 and 10 min reduced the total bacterial count for 1.8 and 4.2 log CFU/g, while the total bacterial count of the Blanching and Hypochlorite treatments was enhanced a little bit. Hence, the DPCD reduced the total bacterial count effectively, and the increasing processing time lead to better effect of sterilization.

![Figure 1. Effect of DPCD Treatments on Total Bacterial Count of Fresh-cut Bitter Gourd.](image)

**Effect of DPCD Treatments on Ascorbic Acid Content of Fresh-cut Bitter Gourd**

The ascorbic acid content of the fresh-cut bitter gourd is shown in Fig. 2. The initial ascorbic acid content of the fresh-cut bitter gourd was 57 mg/100 g. The DPCD treatments reduced the ascorbic acid content for about 83 %. And the time of the DPCD treatment showed no influence on the ascorbic acid content. The similar tendency is also present in the cherry tomato [15] and fresh-cut carrot [16]. These phenomenon could be explained that the high pressure leaked the membrane and the ascorbic acid flowed away during the processing [17]. Remarkably, the ascorbic acid content of the control, hypochlorite, and blanching treatment was significant higher than that of the DPCD treatments.
Effect of DPCD Treatments on pH of Fresh-cut Bitter Gourd

The effect of DPCD treatments on pH value of fresh-cut bitter gourd is shown in Fig. 3. The pH value of the Hypochlorite and Blanching treatments was similar to that of the control, while the pH value of the DPCD treatment was significantly lower than that of the control. The dissolution of the CO₂ could respond the reduction of the pH value after the DPCD treatment [17].

Effect of DPCD Treatments on Total Soluble Solid Content of Fresh-cut Bitter Gourd

The effect of DPCD treatments on total soluble solid content of fresh-cut bitter gourd is shown in Fig. 4. The total soluble solid content of each treatment was similar to that of the control. Hence, DPCD treatment hold the nutrient component of the fresh-cut bitter gourd.

Conclusions

The DPCD treatment reduced the total bacterial count effectively, and the increasing processing time lead to better effect of sterilization. Meanwhile, the DPCD treatment showed no influence on the total soluble solid content of the fresh-cut bitter gourd. However, the DPCD treatment reduced the ascorbic acid content and pH value of the fresh-cut bitter gourd.
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