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Effects of cooling methods on the cooling efficiency and quality of cooked rice

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Abstract

Rice is an important staple food, and often used in ready meals, which should be cooled rapidly after cooking. In the current research, cooked rice was cooled by vacuum cooling, air blast cooling, cold room cooling and plate cooling. It was found that vacuum cooling could chill the cooked rice with much shorter time but with higher weight loss than the other cooling methods. Vacuum cooling of the rice under different conditions could lead to changes of the cooling time and weight loss. If lower final pressure was used in the cooling process or less weight of cooked rice was vacuum cooled, shorter vacuum cooling time and lower weight loss could be obtained. If the rice was cooked for longer boiling time or was vacuum cooled with excess water, the cooled rice could have higher moisture content, but the cooling time would be prolonged significantly. Spraying water during vacuum cooling did not significantly prolong the cooling time, but increased the moisture content of cooled rice. On the other hand, longer boiling time, cooling with excess water and spraying water could reduce hardness of the cooled rice significantly. Only spraying of water could cause significant reduction in the adhesiveness of the rice.

Keywords: Cooked rice; Vacuum cooling; Air blast cooling; Cold room cooling; Plate cooling; Ready meals; Efficiency; Weight loss; Quality; Hardness; Adhesiveness

1. Introduction

Rice is one of the important staple foods in our daily life. With the increasing popularity of ready meal, many products with chilled cooked rice have been developed. In the manufacturing procedure of ready meal containing rice, high hygiene is required. The cooked rice must be chilled to less than 10 °C as quickly as possible to avoid multiplying of survival bacteria during the cooling procedure (Anonymous, 1989, 1991). On the other hand, 4 °C is the temperature at which the degree of retrogradation is expected to be the highest in rice starch (Siddhuraju & Becker, 2003), while good tasting rice requires low retrogradation (Umekuni, Kainuma, & Takahashi, 2003). Therefore, the temperature of 4 °C must be spanned as rapidly as possible. However, little research on cooling of cooked rice is available in the literature. Kemp and Hopkins (1999) proposed a process to prepare cooked rice product in package. In their work, cooked rice was cooled in a cold water bath following by a packaging procedure. In another research, cooked rice was cooled with water directly, and then sterilized in autoclave after packaging (Hernandez-Callejas, Hernandez-Callejas, & Franco-Balibrea, 2000).

Cooling treatments can give influence on the qualities of rice (Hae, Ha, & Soo, 1999). In general, the rice qualities are evaluated based on its colour, eating qualities, flavour, and other attributes like glossiness, looseness

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and kernelness (Yadav & Jindal, 2001). For the colour of rice, it is usually required to be white. However, this is not always the case. For example, some rice such as parboiled rice is yellowish. Eating qualities of cooked rice can be evaluated by instrumental tests (Tan & Corke, 2002). The texture of cooked rice is not a single attribute, instead, it is a composite of several attributes, such as hardness or firmness (or its opposite, tenderness), stickiness or adhesiveness (Juliano, Perez, & Barber, 1981), chewiness and cohesiveness (Yang & Huang, 1996), as well as moistureness to touch (Ramesh, Bhattacharya, & Mitchell, 2000).

In this study, as an advanced efficient cooling method, vacuum cooling is introduced to chill the cooked rice. The efficiency of vacuum cooling is compared with traditional cooling methods, including blast cooling, plate cooling and cold room cooling. Further studies will also be carried out to investigate the effects of weight of cooked rice, final pressure, boiling time, excess water and water spraying on vacuum cooling time and quality of the rice.

2. Materials and methods

2.1. Cooking method

Silvo USA parboiled long grain rice was used in this study. Except additional specification, about 400 g rice (two cups) was soaked for 30 min. After drainage, the rice was rinsed three times with about 4 l tap water for each time, and then mixed with five cups of tap water (about 1240 g) in a pot. After the rice was heated to boiling on a cooker (Model 9934, Russell Hobbs, UK) with full power, the rice was cooked by simmering at half power for 15 min.

After drainage of excess water from the cooked rice, the rice was removed from the pot and placed on a stainless tray for vacuum cooling, air blast cooling or cold room cooling, or packed into a zip bag for plate cooling. The surface of the pile of rice in the tray was flattened in the tray. The rice was cooled from average temperature of between 80 and 90 °C until the temperature dropped down to less than 4 °C.

2.2. Cooling methods

2.2.1. Vacuum cooling

Fig. 1 shows the vacuum cooling system used in the experiment (Sun & Wang, 2001, Chap. 7). Before cooling, vacuum pump was warmed up for half an hour so that the system was stable. Unless otherwise specified, final pressure without food within the vacuum chamber was set at 4.7 mbar by adjusting the bleeding valve in the vacuum vessel. The leakage was kept constant during the whole cooling procedure. After the tray of cooked rice was placed onto a balance (Model FB12CCE, Sartorius AG, Germany) in the vacuum chamber, vacuum cooling began. Between the tray and the balance, there was a layer of heat insulation material in order to avoid the heat transfer between the balance and the tray. If water was needed to spray on to the cooked rice, a syringe valve was opened when pressure within the chamber declined to between 50 and 40 mbar. Approximately 200 ml tap water in a 1000 ml flask was suctioned into the chamber and sprayed onto the rice, under the pressure difference between the atmosphere and the vacuum in the chamber. In all vacuum cooling experiments, no coolant was supplied to the condenser. All experiments were repeated for five times.

2.2.2. Blast cooling

Cooling temperature was set at 1 °C. During the whole cooling procedure, the average temperature of the blasted air from fans was about 3 °C. The blast chiller (Model CBF20, Foster Refrigerator Ltd. UK) had been running for at least 15 min before cooling the food. The tray was placed into the chiller chamber at about 70 mm in front of the fans. Five replicates were accomplished.

2.2.3. Cold room cooling

Cold room cooling was carried out in a refrigerator (Unit 136a, AGB Scientific Ltd., Ireland) at its highest

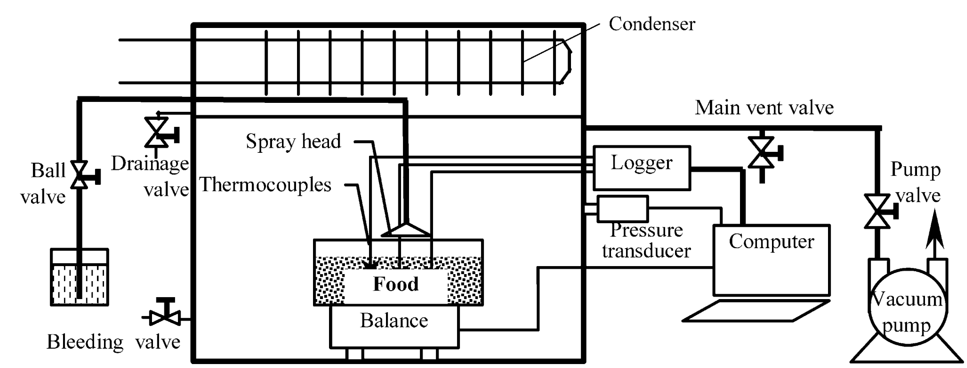

Fig. 1. Schematic figure of the vacuum cooling system.