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Emerging Technologies In Food Processing

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Abstract

Food processing involves the transformation of raw animal or plant materials into consumer-ready products, with the objective of stabilizing food products by preventing or reducing negative changes in quality. Without these processes, we would neither be able to store food from time of plenty to time of need nor to transport food over long distances. Nowadays, consumers are not only concerned about the sensory characteristics of food products (e.g., texture, flavor, aroma, shape, color, and aftertaste), they also pay more attention to their nutritional value. In general, consumers are demanding more minimally processed and additive-free food products. A goal of food manufacturers is to develop and employ processing technologies that retain or create the desired sensory and nutritional qualities, reduce undesirable changes in food due to processing, and extend the shelf life of food products.

There are a variety of preservation technologies that have been extensively used in the food industry, including physical (e.g., heating, freezing, chilling, dehydration, and packaging) and chemical (e.g., reduction of pH or use of preservatives) preservation methods. The basis of these traditional methods involves reducing microbial growth and metabolism to prevent undesirable chemical changes in food. Of the aforementioned preservation technologies, thermal treatment (e.g., pasteurization, sterilization) is probably the most commonly used. Although heating food effectively reduces levels of microorganisms, such processing can alter its natural taste and flavor, and can destroy its nutritional quality.

Therefore, alternative or novel food-processing technologies are being explored and implemented to provide safe, fresh-tasting, nutritive foods without the using heat or chemical preservatives. Innovative non-thermal processes for preserving food have attracted the attention of many food manufacturers. In the search for new processing methods, particularly for certain products, the application of high-pressure (HP) processing has been regarded as a promising alternative to thermal treatments, in terms of ensuring safety and minimizing the processing effects on quality properties. Unlike heat treatment, proper HP treatment does not reduce the quality of foods, and pressure is evenly and instantaneously transmitted throughout the sample, which allows products without over-treated parts to be obtained. Moreover, HP technology has shown some potential for enhancing several food processes (e.g., extraction, freezing, thawing), as well as modifying the physicochemical properties of functional ingredients in some foodstuffs.

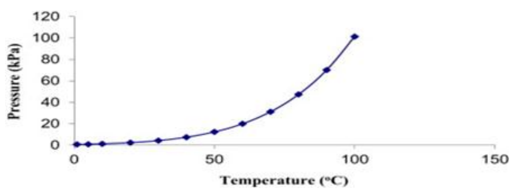
Keywords:

Introduction

Vacuum cooling is achieved through evaporation of part of a product's moisture under vacuum conditions. The major characteristic of vacuum cooling is that the product can be cooled at extremely high speed, unsurpassed by other conventional cooling methods. The first commercial vacuum cooler was installed in 1948, for pre-cooling iceberg lettuce, to remove field heat after harvest and to prolong product shelf-life (Anon, 1981). Subsequently, its application was broadened to other agricultural produce such as mushrooms, cabbage, celery, and cauliflower, among others (Rennie, 2006). The rapid cooling times have stirred interest in other sectors of the food industry (e.g., bakery, fishery, sauces, particulate foods, etc.) More recently, the integration of vacuum-cooling into the processing procedures of prepared consumer foods such as cooked meats and ready meals (e.g., meat pies and pasta dishes) has widened the application of this technology in line with increasing demands from consumers for safe and high quality products, and from the food industry and regulatory bodies for rapid cooling methods that meet food safety guidelines and speed up processing times.

VACCUM COOLING PRINCIPLE:

It is well known that when a liquid evaporates, it needs to absorb heat to attain the higher energy level of molecular movement in the gaseous phase. The amount of energy required is called latent heat, and it must be supplied from the surroundings or from the product itself, either of which will consequently be cooled. The temperature at which evaporation starts is called the liquid saturation temperature and it depends on the surrounding vapor pressure. As can be seen from the saturated temperature pressure relationship for water (Figure 26.1), at a pressure of 1 atmosphere, water boils at 100 C, and a reduction in the imposed pressure will cause water to evaporate at a lower temperature. Any product containing free water, if placed in a closed vessel in which the pressure is reduced, will reach a point at which the vapor pressure difference between the water in the product and the surroundings will cause water to evaporate, with the generated vapor escaping to the surrounding environment. Since the product is in a closed system, latent heat required for evaporation has to be furnished through the conversion of sensible heat; consequently, the product's temperature is reduced. The cooling effect continues, corresponding with the pressure reduction exerted by the vacuum pump. This process is called vacuum cooling, and it is achieved by boiling part of the moisture of the product under vacuum conditions. The final product temperature can be controlled precisely through the regulation of the final vapor pressure inside the vessel, which is usually set at no less than 6.5 mbar to prevent freezing, which otherwise may occur and damage the product.



VACCUM COOLING PROCESS:

A food product (represented by the elliptical shape) with an initial temperature Ti is loaded into the vacuum chamber and the door is closed (Figure 26.2(a)). The vacuum pump is switched on. Air is evacuated and the chamber pressure P starts to decrease. In Figure 26.2(b), although P is lower than the atmospheric pressure, it is still higher than the initial working pressure Psat (which is the saturation vapor pressure corresponding to Ti) and thus not sufficient for evaporation to occur. Consequently, temperature change in the product is still unnoticeable. When P reaches Psat, water inside the product starts to evaporate and latent heat is released (Figure 26.2(c)). The product temperature decreases and, as a result, Psat. The beginning of boiling is called the flash point (Wang and Sun, 2002a). Generally, the chamber pressure should be reduced to the flash point as quickly as possible, because above this point, the vacuum pump merely evacuates air and no cooling takes place. If the generated vapor is continuously removed by the vacuum pump and/or through condensation if a condenser is installed inside the chamber, the internal chamber pressure P is continually kept below Psat (Figure 26.2(d)). This encourages water evaporation to continue and thus the cooling process continues. This cooling process ceases when the desirable product temperature Tf is reached (Figure 26.2(e)). Then, the pump is stopped, the ventilation valve is opened, air is readmitted into the chamber, and products are taken out for storage at the recommended temperature.

VACCUM COOLING EQUIPMENT:

Vacuum-cooling installations vary in size and shape, depending on the individual application. However, the basic components are similar which consisting of a vacuum chamber, a pumping system, and associated pipe works and controls. The vacuum chamber is where the food product is placed and cooled. It is normally floor mounted and oriented horizontally, with either a rectangular or circular cross section, and has one or two doors that are hermetically sealed and either sliding open or hinged.

VACUUM COOLING APPLICATIONS:

1. Fruits and Vegetables:

The quality of vegetables begins to deteriorate on harvesting and continues to decline quickly thereafter. The deterioration can be caused by numerous factors, including physiological breakdown, moisture loss, and microbial decay, most of which are strongly related to time and temperature. Hence, it is desirable to cool vegetables as soon as possible to extend their shelf life. Air blast cooling, hydrocooling, and vacuum cooling are the most commonly used cooling methods for fruits and vegetables. Water flow accounts for about 10% of the operational energy requirement of a hydrocooler, and because the optimum flow depends on the size (diameter) of the product being chilled, among other factors, it is usually used for small products such as peas, asparagus, sweet corn, carrots, and peaches, especially after blanching (Bailey, 1994; Thompson and Singh, 2008). Air blast cooling is achieved through heat transfer from the center of the product to its outer surface via conduction, and then from the outer surface to the circulating air by convection. Although it is a rapid cooling method for non-leafy vegetables, its cooling rate is found to be slow when applied to leafy vegetables, because the air gap between the leaves restricts the heat transfer process due to its low thermal conductivity (Sun, 2000). Hydro cooling pumps have a lower heat input and electricity use compared with the fans used in forced-air cooling, while vacuum cooling has no heat loads other than the product being cooled (except when product water spraying is used). Vacuum cooling thus offers the highest energy efficiency of the three methods. Electricity use is also reported to be very low for vacuum cooling.

2. Bakery products:

In the bakery industry, rapid cooling of products before storage is essential in order to avoid vapor condensation inside the packaging. Vacuum cooling can V. INNOVATIONS IN FOOD REFRIGERATION 26.3 VACUUM COOLING APPLICATIONS IN THE FOOD INDUSTRY 481 accelerate the cooling process for a wide range of baked and partly baked products, including bread rolls, crusty breads, sausage rolls, croissants, pastries, biscotti bread, cakes, and baked biscuits. It is commercially used in Italy for many of these products, including some delicate bakery products such as panetonni, a traditional Italian cake .Panettoni has a high fat and sugar content, which gives the product a delicate structure, prone to collapse during cooling. Using vacuum cooling, panetonni can be cooled in 4 min in comparison to 24 h by air. The cooling process can be operated either in batches or continuously.

3. Sauces, soups and particulate foods:

Vacuum cooling can be used by the food industry to rapidly reduce the temperature of liquid foods by means of the evaporative cooling effect. This cooling method is particularly appealing for liquids containing heat sensitive components such as vitamins and flavors, because the boiling point of water decreases with reducing pressure. Many viscous food products and components (e.g., sauces, soups, meat slurries, and fruit concentrates) are difficult to cool due to the high heat transfer resistance caused by the high viscosity and their low thermal conductivity. This difficulty, however, can be overcome by vacuum cooling, because the cooling effect is mainly achieved through water evaporation rather than conductive or convective heat transfer. Vacuum cooling can also be used to cool and concentrate the product in one step. Care must be taken if solute crystallization is to be avoided, as the solubility of most compounds decreases with reducing temperature. McDonald and Sun (2000) reported the use of vacuum cooling for soups and sauces. Cooling a concentrated blueberry juice product and tomato and meat sauces are some of the examples presented by Zheng and Sun (2004) in their comprehensive review of vacuum cooling applications. It is now a common practice in the production of frozen and chilled ready meals, and its benefits to the food manufacturers are large (DiRisio, 1990; Houska et al., 1996; James, 1990, 1997; Shaevel, 1993). For instance, it was reported that it only took 5 min to vacuum cool a concentrated sugar solution (with 61% dry matter) made from blueberry fruits during the preparation of yogurts, from 90 to 50 C (Houska et al., 1996). Vacuum cooling can also reduce the temperature of 3785 L of tomato sauce from 93 to 7 C in 14 min (DiRisio, 1990). Research also shows that a large batch of meat sauce that weighed 1100 kg could be cooled from 85 to 10 C in less than 30 min using vacuum cooling, which, in contrast, took more than 6 h when air blast cooling was used (James, 1997). In this type of vacuum-cooling system, products are placed inside a jacketed sealed vessel, cooked under pressure, and then vacuum cooled. The vessel may also be installed with scraper blades to avoid the adhesion of products to the vessel wall due to their viscous nature (Anon, 1981). Since the same unit is used for both cooking and cooling, the overall process time is reduced, as no delay is incurred due to the transfer of product between vessels.

ADVANTAGES OF VACUUM COOLING:

- In an account of fruits and vegetables it shows increased product life, short cooling time results in quick distribution, accurate temperature control, low running cost, uniform cooling.
- In case of bakery products it shows rapid cooling rate, suitable for delicate products, increased productivity, superior product quality, absence of molds during cooling, weight loss minimized by reducing baking time.
- In case of sauces and other things it is efficient for viscous products with low thermal conductivity, cooking and cooling integration may be possible, weight can be reduced by adjusting product composition.

DISADVANTAGES OF VACUUM COOLING:

- In case of fruits and vegetables it is applicable mostly to leafy vegetables and mushrooms, high rate of capital cost and high weight loss.
- In an account of bakery products it has some loss of some volatile aromatic components, specialized modulated vacuum cooling technology required for satisfactory results.
- In case of sauces and other things it is difficult in operating as a continuous process, extensive cleaning may required.

CONCLUSION:

Vacuum cooling is a rapid cooling technique that is achieved through boiling part of the moisture of the product under vacuum conditions. Any product can be vacuum cooled provided that it is porous and can afford to lose a proportion of its water content without having adverse effects on its quality. As a well-established commercial method for cooling leafy vegetables, mushrooms, and some delicate bakery products, it can also be used to cool viscous and particulate food products such as sauces, meat slurries, and fruit concentrates, which, due to their high viscosity and low thermal conductivity, are usually difficult to cool using traditional methods. In the past few years, increased competitiveness and safety concerns have advanced research on the vacuum cooling of cooked meat products and ready meals, which indicate that benefits are large and its potential is promising. As an innovative cooling technique, vacuum cooling brings significant benefits to the food industry, in particular in terms of reducing production costs and improving product quality and safety. For some products, however, vacuum cooling still results in unacceptably high cooling losses, which decreases product yield and may affect product quality. Therefore, further research efforts to explore new methods for compensating for cooling loss and its subsequent effect on product yield and quality are ongoing. As research work continues on increasing the practical applications of vacuum cooling and improving the quality of vacuum-cooled products, its uptake by the food processing industry will most likely increase, making it more competitive and widespread in the future.

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