Chapter 5
Closed Refrigerated Display Cabinets: Is It Worth It for Food Quality?

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ABSTRACT

The use of closed refrigerated display cabinets in supermarkets is in progression because of the potential energy saving compared to the open ones with an air infiltration at the front. However, the influence of the presence of doors on product temperatures (determining factor of product quality) is much less studied. For better understanding the interest of the use of closed display cabinets, this chapter presents the state of the art of field studies, the airflow and temperature profile in the closed display cabinet, the influence of the presence of doors/the frequency of door openings and the room temperature. Finally, a literature review of studies on food quality in the closed display cabinet is presented.

INTRODUCTION

Numerous studies on retail refrigerated display cabinets have been carried out over the past two decades, awareness of food product quality and energy efficiency is rising continuously. Open display cabinets are a refrigeration equipment typical used for food display in retail stores. In this cabinet type, there is no physical barrier between customers and products, except an air curtain which allows infiltration of warm and humid air from surroundings. This issue still poses problems in many research and development contexts even through plenty of research studies were undertaken by means of both experimental and numerical approaches. The application of closed doors is becoming an alternative solution and

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several studies have demonstrated that fitting cabinets with doors can provide several benefits. Since there is no clear observation on the loss of sales of products due to the use of doors, many researchers are conducting investigations on the influence of the presence of doors. Nevertheless, most of these studies focused on the energy efficiency perspective. Its impact on internal temperature variations, which directly affect food quality and safety, requires further elucidation. The objective of this book chapter is therefore to highlight the new trend for the use of closed display cabinets in supermarkets and its associated implications on food quality.

BACKGROUND

About 66-77% of heat input in an open refrigerated display cabinet come from the infiltration of warm and humid ambient air in a supermarket (Gaspar, Carrilho Gonçalves, & Pitarma, 2011; Tassou, Ge, Hadawey, & Marriott, 2011) which is one of the main causes of internal temperature heterogeneity. Temperature differences of more than 5°C can be found on cabinet shelves (Willocx, Hendrick, & Tobback, 1994) where the highest temperature is regularly located at the front of the cases (Evans, Scarcelli, & Swain, 2007; Laguerre, Hoang, Osswald, & Flick, 2012). To overcome this major drawback, installation of doors becomes an alternative and attracts more and more attention, and it will account for 75% of all display cabinets in retail stores by the end of 2020 in France (RPF, 2016). Closed refrigerated display cabinets have been increasingly used because of their potential energy savings of between 20-70% (Fricke & Becker, 2010; Lindberg, Axell, & Fahlén, 2010; Rhiemeier, Harnisch, Ters, Kauffeld, & Leisewitz, 2009; Rolfsman & Borgqvist, 2014). Such savings were mainly achieved through a reduction in the entrainment of ambient warm and moist air into the shelves-space storage, thus, less frost is deposited on cooling coils and compressor energy demand becomes less (Faramarzi, Coburn, & Sarhadian, 2002). The difference in the energy consumption from these studies depends on a number of factors, for example, the number of door openings, the door itself, the door seals/gaskets and the level of air infiltration during door openings (Evans, 2014). Among these influencing factors, the frequency, duration of door openings and air gaps between the doors are important which can result in higher energy consumption (Li, Zhu, Wang, & Zeng, 2007). The refrigeration energy consumption of closed display cabinets during stable night condition was approximately 10% lower than that of the display cabinet operated under periodically door openings (Vallée, 2015). Despite these findings, the energy consumption between these two cabinet types may not significantly different when the estimation of the mean total energy consumption is based on a unit display area because of the difference of cabinet design (Evans & Swain, 2010). Further research is required to access additional data.

Temperature performance of closed refrigerated display cabinets was investigated particularly in regard to spatial and temporal temperature variations. A decrease in the overall air temperature of at least 2°C in display cabinets was achieved when retrofitted with doors (Lindberg et al., 2010). Chaomuang, Flick, Denis, and Laguerre (2019) reported that the studied cabinet with doors provided less temperature heterogeneity (ΔT_{max}=2.1°C) compared to the case without doors (ΔT_{max}=4.9°C). About 124 closed display cabinets were tested by Evans and Swain (2010) and the comparative results obtained with open and closed display cabinets revealed that the temperature variation within the closed cabinets was lower than that within the open ones. About 94% of the products with the highest temperature were located at