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A real-time risk control and monitoring system for incident handling in wine storage

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ABSTRACT

Due to the fact that wine is highly sensitive to storage conditions such as temperature and humidity, it is a challenging task for a regional distribution hub to provide reliable wine storage facilities for maintaining wine quality during storage. This is especially true when an incident occurs unexpectedly that violates the criteria of suitable storage conditions. Improper incident handling and storage conditions may cause damage to the taste of wine, resulting in depreciation of the wine's value. Therefore, controlling and monitoring risk in real-time during wine storage is critical to providing a quick response to prevent the wine quality from deterioration. In this paper, a RFID-based risk control and monitoring system (RCMS), which integrates radio frequency identification (RFID) technology and case-based reasoning (CBR), is proposed for monitoring real-time physical storage conditions and for formulating an immediate action plan for handling incidents. In the retrieval process of the CBR engine, genetic algorithms (GA) are applied to search for case clusters by considering the best combination of multi-dimensional parameters. With the help of RCMS, a shortlist of critical control actions, possible causes of incidents and corresponding actions can be generated to reduce the risk of deteriorating wine quality and possible compensation costs being incurred, while customer satisfaction can be maintained.

1. Introduction

In recent years, the global demand for wine has shifted from traditional wine consumption markets such as Europe and America to Asia, while the demand for wine is forecast to grow further in the coming years. However, due to lack of suitable conditions for wine production in most Asian countries, wine is usually imported from Europe markets to fulfill the increasing demand. Thus, the need for regional wine distribution hubs, that can serve a wide geographic region, has raised the concern to centralize business activities for achieving global economies of scale (Garcia, Marchette, Camargo, Morel, & Forradellas, 2012; Oum & Park, 2004).

Classified as a high value product, wine is expensive in price and of a high standard in terms of quality. Besides, in the current trend, wine is not only purchased for direct consumption, increasing demand is focused on long term investment and private collection. As shown in Fig. 1, wine can be classified into two categories, which are commercial wine and fine wine. Commercial wine is usually made for fast consumption and has a fast turnover rate and short storage time. Most fine wine is used for private collections and undergoes long term storage. Such wine may further improve its taste and quality by being stored under proper storage conditions. In addition, both of the wines are highly sensitive to both internal and external environments, and are especially affected by temperature, humidity, light and vibration. If they are not handled properly during storage and transportation, not only the taste of wine will be damaged, it could also cause depreciation of wine's value (Pullmand, Maloni, & Dillard, 2010). Therefore, having reliable wine storage facilities in a regional wine distribution hub is critical to maintaining the value and taste of wine along the wine supply chain. Based on the special characteristics of wine, the wine distribution hub should be (i) able to handle both commercial and fine wine at the same time, (ii) able to provide appropriate infrastructures that prevent excessive light and vibration affecting the quality of the wine, (iii) able to closely monitor the physical conditions of the storage area (i.e. temperature and humidity) to ensure the quality of the wine, and (iv) able to provide a quick response and take immediate action when any incident occurs.

Fig. 2 shows the existing incident handling problem caused by inadequate physical condition monitoring operations. According to HKQAA (2010), there are different temperature and humidity requirements specified for fine wine and commercial wine. The temperature for fine wine and commercial wine are 11–17 °C and 22 °C respectively while the humidity at any point inside the storage area are 55%–80% and smaller than 50% respectively. Thus,

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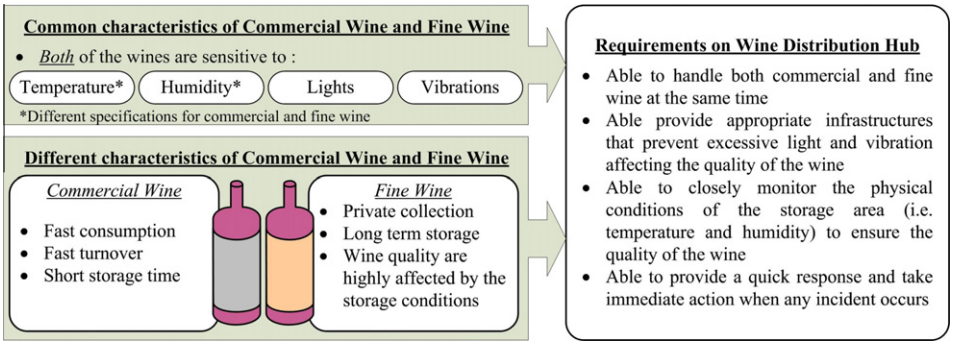

Fig. 1. Requirements of a wine distribution hub based on the wine characteristics.

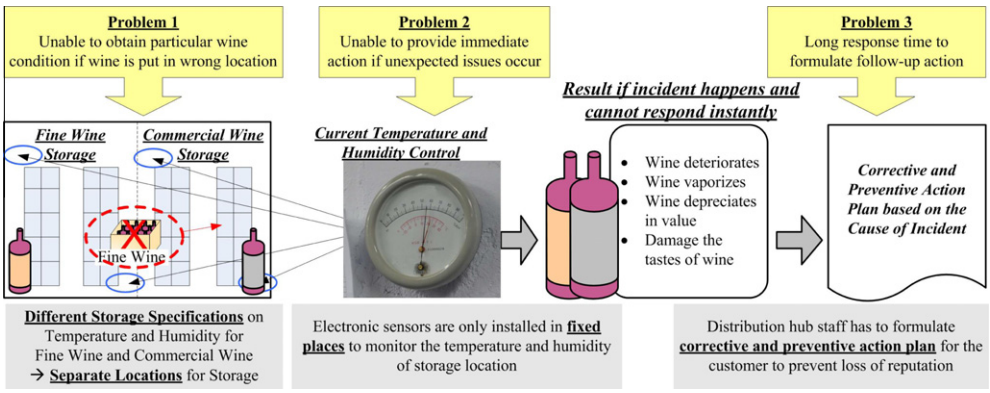

Fig. 2. Existing incident handling problem caused by inadequate physical condition monitoring operations.

the two categories of wine should be kept separately in designated locations where electronic sensors are installed in fixed places to continuously monitor the physical storage conditions. However, only the room temperature and humidity where the sensors are located can be measured while blind spots can still exist in a huge storage zone even with sufficient refrigerating facilities. If fine wine is put in the wrong commercial wine storage area, the existing sensor system is unable to notify and measure the actual temperature and humidity. The wine could then deteriorate rapidly and depreciate in value. On the other hand, as the actual physical conditions of particular wine cannot be measured in real-time conditions, the necessary action cannot be taken immediately if an incident occurs. Thus, the distribution hub may suffer loss. In addition, without the information on the possible cause of incident, it may take a long time to formulate follow-up action to mitigate such risks.

In this paper, a RFID-based risk control and monitoring system (RCMS), which integrates radio frequency identification (RFID) technology and the case-based reasoning (CBR) technique, is proposed to monitor real-time physical storage conditions and formulate a follow-up action plan when an incident occurs. By applying the RFID technology, temperature and humidity for each SKU of wine is captured and monitored in real-time so that immediate action can be taken when storage conditions change abnormally. Besides, CBR technology is applied to formulate an appropriate solution which includes feasible corrective and preventive action plan by retrieving past relevant knowledge. With the help of RCMS, a shortlist of critical control actions, possible causes of incidents and corresponding actions can be generated to reduce the risk of deteriorating wine quality and possible compensation cost incurred while customer satisfaction can be maintained. This paper is organized as follows. In Section 2, literature related to recent developments in the wine industry, risk control and monitoring of quality measures, RFID and the CBR technique are studied. Section 3 presents the system architecture of RCMS. In Section 4, a case study is presented to demonstrate the implementation procedures of the system. In Section 5 the results and benefits of launching the system are discussed while a conclusion is drawn in Section 6.

2. Literature review

Wine has a unique and complex nature compared to other fast moving consumption goods as there is a specific wine production cycle, while the production highly depends on the climatic conditions, origin and quality of the grapes (Bernabeu, Brugarolas, Martinez-Carrasco, & Diaz, 2008; Getz & Brown, 2006; Hollebeek, Jaeger, Brodie, & Balemi, 2007). Regions that are able to provide suitable conditions for wine production are limited. Generally, wine can be classified into two categories according to the countries where it is produced, which are the "Old World" including France, Italy and Spain, and "New World" such as the United States, Australia, Chile and New Zealand (Campbell & Guibert, 2006). Other non-wine producing countries can only import wine to fulfill the increasing demand for wine (Somogyi, Li, Johnson, Bruwer, & Bastian, 2011). The wine supply chain has therefore shifted from the local market to external markets. Wines are shipped to target markets for consumption. Hence, the establishment of a regional distribution center to serve a wider geographic region is critical in order to lower the total logistics cost and increase the sales volume (Hussain, Cholette, & Castaldi, 2008; Cholette, 2009; Cusmano, Morrison, & Rabellotti, 2010). However, as there are strict requirements for handling wine, which is fragile and sensitive to the external environment, it is a challenge to manage the operational conditions during storage.

Different from general food and beverage products with a limited shelf life, wine has the special characteristic of aging potential