

In brief, the polypropylene film, filter paper and calcium silicate type 1 (CaSE-1) were found to release volatile oil into the headspace more effectively than thyvex, LLDPE, LDPE35 and LDPE 70 with silica gel and calcium silicate type 2 (CaSE-2). The results from the volatile headspace showed that major volatiles in the headspace above an inhibitory mixture of these oils were *p*-cymene, linalool, cinnamaldehyde and eugenol. Furthermore, the result from the experiment showed that 10% of compound in the headspace could be adsorbed into a surface of fruitcake inside the packaging. Therefore, the polypropylene film and calcium silicate type 1 (CaSE-1) was used for further investigation in this section and the polypropylene film and filter paper was used for further investigation in section 4 (applying the active packaging technique developed to preserve the IMF products under normal air condition).

3.2 Storage of premix fruitcake (PMC₅) and rice fruitcake (RF) with active packaging condition

3.2.1 Total bacteria, yeast and mould: The microorganism colonies

appeared on the surface of both PMC₅ and RF packed with high CO₂ after 14 days. The volatile oil headspace in combination with high CO₂ could extend the shelf life by 7 days at 20 °C by preventing the growth of yeast, mould and bacteria for up to 21 days (3 week) at 20 °C (Table 16 to 17). The microbial analysis for premix fruitcake (PMC₅) is shown in Table 16 and the microbial analysis for rice fruitcake is shown in Table 17. Colonies of microorganisms appeared on the surface of rice fruitcake packed with high CO₂ level of 40% after 14 days. The presence of volatile oil headspace in combination with high CO₂ was found to extend the shelf life of rice fruitcake by 7 days and preventing the growth of yeast, mould and bacteria for up to 21 days. The results showed that different storage conditions (20°C, 68%RH and 30°C, 75 %RH) did not affect the growth of microorganisms within the modified atmosphere active packaging condition examined. The results obtained within this work showed that there is possibility of using the volatile phase of essential oils in combination with high CO₂ levels to increase the shelf life of rice fruitcake over that of using high CO₂ alone.

Nielsen and Rios (2000) reported that high CO₂ level ($\geq 40\%$) could prevent the growth of mould on agar for more than 7 days. Guevara *et al* (2003) noted that the high CO₂ and low O₂ could maintain a good quality for food products. The results here showed that there is possibility of using the volatile phase of essential oils in combination with high CO₂ levels to increase the shelf life of rice fruit cake over that of using high CO₂ alone.