regression is attempted to determine the relationship between the response variable and a subset of the independent variables.

4.2.5 Verification of cinnamaldehyde headspace modeling

The 700 ml plastic jar (PET type) was used to search for experimental yield (concentration of cinnamaldehyde in the headspace). The plastic jar was 110 mm wide x 110 mm long x 60 mm deep (Nam Ngai Hong LTd., Thailand). The small sachet (5 x5 cm. of polypropylene film) was made by adding 50 µL and 100 µL of a 5:1 mixture of cinnamon and clove oils into 5x5 filter paper NO.6. (Whatman International Ltd, England) and was placed inside a plastic jar. The packaging was kept at 40 °C for 10 min and 1 mL gas samples were removed for analysis using a gas-tight syringe (Hamilton Gastight®, USA) at varying times via a rubber septum fitted to the lid. The GC condition was explained in 4.2.3.

4.3 Storage of rice jasmine butter cake with normal air condition

4.3.1 Rice jasmine butter cake packaging

Rice jasmine butter cake (Kasetsart Agricultural and Agro-Industrial Product Improvement Institute, Kasetsart University, Thailand) were processed to make a cake following: preheat oven for 10 minutes at 160°C, then mix 173 g butter with 40 g EC 25 K emulsifier on low speed in the large bowl, add sugar and 300 g eggs plus 500 g premix butter cake with 68 g milk into the bowl, using beater combine on low speed and scrape down bake for 30-35 minutes. A 5 x 5 cm piece of rice butter cake slice (~5 cm thick) was also placed inside the 700 ml small jar. The 700 ml small jar (PET plastic type) was 110 mm wide x 110 mm long x 60 mm deep (Nam Ngai Hong LTd., Thailand). The small sachet (5 x5 cm. of polypropylene film) was made by adding 50 µL and 100 µL of a 5:1 mixture of cinnamon and clove oils into 5x5 filter paper NO.6. (Whatman International Ltd, England) and was placed inside a plastic jar. The packaging was kept at 40 °C for 10 min before kept inside 30 °C incubator for 1 month and kept at room temperature with wet bulb and dry bulb

temperature by thermocouple for another experiment. 1 mL gas samples were removed for analysis using a gas-tight syringe (Hamilton Gastight®, USA) at every week for 1 month via a rubber septum fitted to the lid

4.3.2 The flavors of essential oil in rice butter cake

The flavors of essential oil in rice butter cake were extracted using ethyl acetate. The method to extract rice fruitcake was explained by Friedman *et al* (2000). GC analysis was carried out on a 3380 GC (Varian, Inc, USA) gas chromatograph equipped with a FID and a DB-5 (J&W Scientific, USA) capillary column (30mx0.25mmx0.25 μm). The oven temperature was held at 60 ^{0}C for 0.50 min then increased at a rate of 40 °C/min to 150 °C and then increased at a rate of 2 °C/min to 260 °C. Other operating conditions were as follows: carrier gas, N_2 with a flow rate of 1 ml/min; injector temperature, 250 °C; detector temperature, 260 °C; split ratio, 50:1. Rice butter cake extract (1 μl) was then injected into the gas chromatograph by using 10 μl of Hamilton syringe (Hamilton Gastight®, USA). The samples were injected into GC every week until 1 month

4.3.3 Total bacteria, yeast and mould

Total bacteria, yeast and mould were analyzed according to Association of Official Analytical Chemists (AOAC, 1995) procedure numbers 933.11 and 2002.11, respectively

4.3.4 Sensory evaluation

Sensory testing was conducted with an untrained panel. A panel of seventy-one consumers (aged between 20-40) selected from students and staff at the Walailak University, Nakon Si Tammarat, Thailand was used in the study. All subjects were butter cake consumers. Evaluation was conducted in taste panel booths.

One piece of the rice butter cake, cut into 5x5 cm, was presented in a small size of jar and was evaluated by consumer by liking ratings on the nine-pointed hedonic scale. At day 0, the consumers were asked to evaluate control and three treated samples packed with 0, 50, 100 µl of cinnamon oil and clove oil at ratio 5:1 in the order were present to them. Liking ratings used the standard nine-pointed hedonic scale “dislike extremely” (scored as 1) to “like extremely” (scored as 9). The sensory test was done every week until 1 month or product spoilage from bacteria or yeast and mould.

4.3.5 Data Analysis

The data obtained from quality evaluation of rice fruitcake during storage were analyzed for statistical significance using the Statistical Analysis System (SAS V8, 2001).

RESULTS AND DISCUSSION

1 Survey of types of IMF products in modern market from the retailers in Bangkok to identify products for preservation by active packaging

1.1 Product survey

The survey of intermediate moisture food (IMF) products available in the modern market in Thailand was carried out from November to December 2003. The products were divided into four categories according to the food composition database issued by the INMUCAL program, Institute of Nutrition, Mahidol University, Thailand (1998). One hundred and thirty six products were found in this survey. There were compromised of 34% meat and meat products, 32% fruits, vegetables, and dessert 29% cereals, legumes, nuts and seeds products, and 5% dairy product (Figure 1). A list of all products surveyed is shown in Table 9. Fungi found within the same product groups should generally be potentially inhibited by similar techniques and conditions subject to difference in properties such as pH, a_w. Therefore, any products within similar product group could be selected for use in the research in order to search for an appropriate method to inhibit fungi. The method obtained should be applicable to inhibit all fungi found in all products within that group. It appears from the survey that varieties of IMF products in the Thai modern market are equally of about 30% by the first three groups of IMF products mentioned above. A price per weight of the IMF products surveyed was between 0.01 Baht/gram to 2.14 Baht/gram. Cereals, legumes, nuts and seeds products, meat and meat products, fruit, vegetable and dessert and dairy product were sold in the range of 0.01to 0.78 baht/gram, 0.12 to 1.02 baht/gram, 0.05 to 2.14 baht/gram and 0.15 to 0.90 baht/gram, respectively

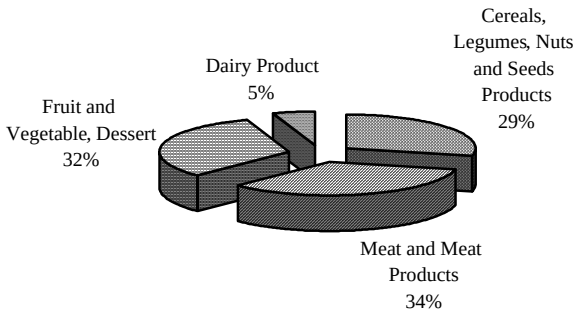

Figure 1 Varieties of 136 IMF products surveyed which were available in the modern market in Thailand

Storage method and product shelf life were also used to classify the IMF products surveyed into three groups. The first group is the rapidly spoiling products such as cheese and fresh noodle. These products are kept inside a refrigerator at temperature between 5°C to10°C to inhibit the growth of microorganisms. The second product group such as honey, ham and dried fish contains sufficient amount of sugar, salt or weak acid to be suitable to put onto a normal shelf at room temperature (between 20°C to 25°C). The product shelf life was from 1 month to 6 months. The final group is the rapidly spoiling bakery product, which must be kept at room temperature to preserve the product texture quality. Since the bakery product contains too small an amount of salt or sugar to prevent the growth of microorganism at room temperature the product shelf life was relatively short only 3 days to 14 days. It is beneficial to extend the bakery product shelf life to allow the product to be sold into a larger area and to decrease the amount of spoiled products left on the shelf. Given all the above circumstances, an active packaging technique using modified atmosphere in combination with volatile of essential oil has high potential to prolong bakery products shelf life with minimal effect on product quality. A screening technique was employed in this work to select a bakery product with potential to be preserved