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Combined Effect of Honey and O_2 Absorber Packaging on Storage Quality of Chocolate Sponge Cake

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Abstract: This study was aimed to investigate the combined effect of honey and O_2 absorber on physicochemical and sensory properties of chocolate sponge cakes stored at room temperature (30±2°C) for 12 days. Four sponge cake treatments included sucrose cake packed without O_2 absorber (T1), sucrose cake packed with O_2 absorber (T2), honey cake packed without O_2 absorber (T3) and honey cake packed with O_2 absorber (T4) were examined. The pH values of sucrose and honey cakes packed without O_2 absorber were significantly decreased ($p<0.05$) whereas those with O_2 absorber were consistent throughout storage period ($p>0.05$). All cake treatments showed significant decrease ($p<0.05$) in water activity in parallel with increasing titratable acidity and firmness values ($p<0.05$). The cakes containing honey were lighter and more yellowish than did the sucrose cakes. As the storage time increased, all cake treatments were darker. Microbiological analysis showed that the sucrose cake packed without O_2 absorber (T1) became moldy after the 6^{th} day of storage, while other cakes exhibited negative mold throughout storage time. Also, Coliform bacteria and *E. coli* counts were not detected in all cakes. Sensory evaluation revealed that sucrose and honey cakes with any packaging did not significantly differ ($p>0.05$) in all attributes scores. After the 3^{rd} day of storage, the cake containing honey significantly showed ($p>0.05$) no alteration in all sensory attributes while the decrease in flavor was evident ($p<0.05$) in the sucrose cake.

Keywords: Chocolate sponge cake, honey, O_2 absorber packaging, shelf life extension

INTRODUCTION

Sponge cakes, which are mainly composed of flour, eggs and sugar, have been extensively produced in various categories and consumed worldwide. These products are considered as convenience foods required for modern-day society. In general, sponge cakes are sold without sealed packaging, together with their high moisture content, these shorten the shelf life primarily caused by the microbial spoilage, followed by physico-chemical changes which indicate poor quality of the products such as staling and lipid oxidation (Adam and Moss, 2000). The addition of synthetic microbial agents (e.g., citric, sorbic, propionic and benzoic acids) has been shown to reduce or prevent microbial growth in bakery products; however, the inefficiency of these substances brings about by their dissociated forms depending on pH of the products (Gutierrez *et al*., 2009). In addition, odor impact affecting sensorial properties and consumer awareness for safety of synthetic chemical preservatives are supporting reasons to find another approach for a longer shelf life.

Active packaging is an innovative technology to improve quality and safety of food products by a concept to change or modify the condition of the packaging to extend shelf life and also to prevent the oxidative change which affects sensory perception. One example was the use of O_2 absorber material within the package to reduce the O_2 levels to less than 0.01% within 1 to 4 days at room temperature (Vermeiren *et al*., 1999). Some investigations have disclosed the application of O_2 absorber in bakery products; for example, the mold-free shelf life of white bread packed in polypropylene bags could be extended from 5 to 45 days at room temperature by introducing an Ageless® sachet (Smith *et al*., 1986). Salminen *et al*. (1996) found that the microbial shelf life of sliced bread was extended considerably by packaging with ATCO® O_2 absorber. They detected that the O_2 concentration decreased to below 0.1% within a few days of packaging and there was no effect of O_2 absorber on sensory quality of bread during storage. Consequently, the active packaging provides a solution in which the shelf life of food products can be considerably extended without affecting quality characteristics.

Another main preservation factor regarding food product shelf life is water activity, which should be set in a range between 0.70-0.80 for controlling the growth of microorganism. This may be achieved by the help of different sugars and polyols. Honey, a natural sweetener comprising of simple sugars, most are fructose (38%) and glucose (31%), has approximately 17.7% moisture, 0.08% total acidity and 0.18% ash content. The average pH of honey is 3.9 while water activity varies between 0.56 and 0.62 (Ouchemoukh

et al., 2007). Also, there is a great variety of minor components, including phenolic acids and flavonoids, the enzymes glucose oxidase and catalase, ascorbic acid, carotenoids, organic acids, proteins and α-tocopherol (Nagai *et al*., 2006). As honey has an antimicrobial property, this could be associated with its high osmolarity, low pH and high level of hydrogen peroxide (Molan, 1992). Honey has been served as a natural food preservative in cereal-based bakery, snack and confectionery products as well as in dairy products. Moreover, it will help provide flavor and sweetness characteristics in these products. Some research is reported by Tong *et al*. (2010) who found the breads containing 5-10% honey powder had higher volume, softer crumb, yellowish color and better baking quality by retarding staling and increasing shelf life. As a result, honey can be added to cake to function as a sweetener together with extending the shelf life of product. Thus, it would be beneficial to develop a novel formulation of chocolate sponge cake with honey. In addition, packaging with O_2 absorber was applied to reduce existing oxygen in a food package for inhibition of aerobic mold growth. Therefore, the objective of this research was carried out to investigate the influence of the combined effect of honey and Wonderkeep® O_2 absorber on physicochemical and sensory properties of chocolate sponge cakes for 12 days storage at room temperature (30±2°C).

MATERIALS AND METHODS

Materials: The ingredients used in the formula of chocolate sponge cakes were cake flour (Royal Fan, United Flour Mill Public Co., Ltd., Thailand), cocoa (Cocoa tulip, Yok intertrade Co., Ltd., Thailand), baking powder (Best Foods, Unilever Thai Trading Co., Ltd., Thailand), nonfat dry milk (Dumex, Dumex, Thailand), cake emulsifier (UFM SP cream, UFM Food Centre Co., Ltd., Thailand), butter (Allowrie, Siam Bakeryland Co., Ltd., Thailand), honey syrup (Vejpong, Vejpong marketing, Thailand), sugar (Mitrr Phol, Mitr Phol group, Thailand) and fresh whole egg, which were purchased from a local supermarket. An O_2 absorber (Wonderkeep®, Powdertech Co., Ltd., Japan) was obtained from Janjaras Chem Supply Co., Ltd., Thailand.

Preparation of chocolate sponge cake: The chocolate sponge cake prepared with honey in this study was slightly modified from the commercial (sucrose) formulation. The experimental studies were conducted approximately 6 month (September-February, 2011) on a Food Science and Technology laboratory, School of Science and Technology, University of the Thai Chamber of Commerce, Bangkok, Thailand. A preliminary test (detailed results are not reported here) was conducted to determine the optimum amount of honey used for sponge cake production. The chocolate sponge cakes elaborated with sucrose and added honey are shown in Table 1. For sponge cake preparation, cake flour, cocoa, baking powder and nonfat dry milk were sifted together into a mixing bowl. Fresh whole egg, water, cake emulsifier and honey (or sucrose) were added into dry mixes and mixed by an egg beater at maximum speed for 5 min. Then melt butter was added and further mixed at low speed for 1 min. Each cake batter (85 g) was immediately deposited into cake pans (5.5×10×3.5 cm) and baked in an oven at 150°C for 30 min. The cakes were cooled down at room temperature for 1 h before removing from the pans.

Table 1: Formulations of chocolate sponge cakes (% in cake flour basis)

Ingredients	Sucrose cake	Honey cake
Cake flour	100	100
Cocoa	25	25
Baking powder	2.6	2.6
Non fat dry milk	15	15
Cake emulsifier	10	10
Whole egg	192.5	192.5
Butter	125	125
Water	12.5	12.5
Sucrose	150	-
Honey	-	200

Packaging method and experimental design: The chocolate sponge cakes were Packed in Polypropylene (PP) high permeability pouches, 40 μm in thickness, having an oxygen permeability of 1500 cm^3/m^2/day/atm (packed without O_2 absorber). For sample packed with O_2 absorber, the cakes were packed in Polyvinylidene Chloride (PVDC) high barrier pouches, 60 μm in thickness, having an oxygen permeability of 3 cm^3/m^2/day/atm, each Wonderkeep® O_2 absorber sachet was placed inside the packages before sealing. The test chocolate sponge cakes included with sucrose cake packed without O_2 absorber (T1), sucrose cake packed with O_2 absorber (T2), honey cake packed without O_2 absorber (T3) and honey cake packed with O_2 absorber (T4). The four cake treatments were stored at room temperature (30±2°C) for 12 days. The cake quality was evaluated for physicochemical properties, microbiological analysis and sensory evaluation.

Physicochemical analysis:

pH: The pH was measured using a pH-meter (Model 320, Mettler-Toledo Ltd., Essex, UK) according to AOAC standard method (AOAC, 1990).

Titratable acidity: Total acidity (mg/100 mL) expressed as lactic acid was determined according to AOAC standard method (AOAC, 1990).

Water activity: Water activity was determined using a water activity instrument (Decagon CX-2, Aqua Lab, Pullman, WA, USA).

Firmness: Firmness of cake sample (4×4×4 cm) was measured using a Lloyd texture analyzer (Model LRX, Lloyd Instruments, Hampshire, UK) with 1000 N load

cell and a shearing-test cell at 250 mm/s. Peak force (N) was recorded and represented as firmness.

Color: The crumb color was measured in the term of L^* (lightness), a^* (redness/greenness) and b^* (yellowness/ blueness) values using a Hunter Lab digital colorimeter (Model Color Flex, Hunter Associates Laboratory, Reston, VA).

Sensory evaluation: Twenty-four untrained panelists drawn from Department of Food Science and Technology, University of the Thai Chamber of Commerce (UTCC) were selected based on their interest and product familiarity. Each sample was evaluated for appearance, texture, color, flavor, taste and overall acceptability using a 9-point hedonic scale test (1 = extremely dislike, 9 = extremely like). Panelists were instructed to cleanse their palates with distilled water before tasting the sample and anytime during the test as needed (Lawless and Heymann, 1998).

Microbiological analysis:

Microbial enumeration: The microbiological analysis was carried out according to AOAC standard method (AOAC, 1998). Sample (25 g) was aseptically weighed and placed in a stomacher bag containing 250 mL of sterile 0.1% peptone diluent and pummeled for 1 min with a stomacher® (Model 400 circulator, Seward Ltd., Ohio, USA). Homogenate was then diluted serially to obtain proper dilution for microbiological test at day 0, 3, 6 and 9 and 12 during storage at 30±2°C, respectively. Total mold counts were determined by spread plating on Dichoran Rose Bengal Chloramphenicol employing an incubation condition at 25°C for 5-7 days. Number of CFU were counted and reported as log CFU/g. For Coliform bacteria counts and *Escherichia coli* counts were determined according to multiple tube technique by using Fluorocult LMX® broth and incubation condition at 37°C for 24-48 h. Counts of these bacteria were expressed as MPN/g.

Statistical analysis: The production of chocolate sponge cakes was made in duplicate and three samples from each treatment were used for physicochemical analysis. Data were analyzed by computer. An Analysis of Variance (ANOVA) was used to evaluate significant difference at level of 5% ($p<0.05$). If a significant F-test was noted, treatment means were separated using the Duncan's New Multiple Range Test (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Physicochemical properties: Results of pH and titratable acidity of various chocolate sponge cake formulations given in Fig. 1a and b show that pH values of the sucrose cakes packed without and with O_2 absorber (T1 and T2) ranged from 7.28 to 7.59, while both of packed cakes containing honey (T3 and T4) had pH values ranged from 6.58 to 6.72 over storage period. The pH of the honey sponge cake was lower ($p<0.05$) than that with sucrose throughout this storage, possibly due to lower pH level (pH 3.2-4.5) of honey and other organic acids such as gluconic acid, which is a byproduct obtained from enzymatic digestion of glucose (Molan, 1992). In the case of sucrose cake packed without O_2 absorber (T1), the pH tended to significantly decrease ($p<0.05$) from 7.59 to 7.28 during storage, while sucrose cake with O_2 absorber (T2) was not significantly different ($p>0.05$). This finding revealed the effect of O_2 absorber for maintaining pH level in the cake from day 0 to 12, consequently implying the lower growth of microorganism as a result of oxygen shortage. The pH reduction found in cake without O_2 absorber may be attributed to the increment of organic acid products by ongoing lactic acid bacteria metabolism. A second possibility may be due to the microbial activity in the product which gives a rise of CO_2 production to react with the aqueous phase of the product to form H_2CO_3 that causes a pH decrease (Mexis *et al*., 2009). One can infer from the result that the application of combined effect of honey and O_2 absorber packaging was significantly evident on the honey sponge cake packed with O_2 absorber (T4), which showed a lower pH than those with sucrose (T1 and T2). As compared with the T3 sample, there was no pH change in T4 sample throughout storage time. The result of pH was supported by titratable acidity determined in all cakes, as evidence in Fig. 1b. Lower acidity was detected in the sucrose cakes (T1 and T2) than did the honey cakes (T3 and T4). Whilst the cake packed with O_2 absorber indicated a lower acidity than that without O_2 absorber.

Results of water activity shown in Fig. 1c show that at initial storage (day 0) water activity observed for sucrose cakes packed without and with O_2 absorber (T1 and T2) were within 0.898-0.901, which were significantly higher ($p<0.05$) than those with honey (0.863-0.866). Overall, water activity values of the honey cakes were significantly lower ($p<0.05$) than those with sucrose, possibly due to the effect of high osmotic pressure and low water activity of honey (Molan, 1992), consequently holding water molecule to remain in cake structure. Obviously, water activity of all cakes significantly decreased ($p<0.05$) during storage, and highly significant reduction in water activity was noticed in sucrose and honey cakes without O_2 absorber in relation to those with O_2 absorber packaging. This finding suggests that the type of packaging is one of parameters concerning on the shelf life of sponge cake; therefore, the cake packed in a polyvinylidene chloride bag, which is better for the water vapor permeable barrier than a polypropylene

bag, showed a slight reduction in water activity throughout storage time. It was noted that, as compared with fresh cake, the reduction in water activity observed for sucrose and honey cakes were evident after the 6th and 9th day of storage, respectively. This revealed an effective retardation of moisture loss by honey in relation to sucrose, which was attributed to the stronger water holding capacity of fructose in honey to absorb or retain more moisture in cake crumb, resulting in higher retention of moisture in cake in consonance with staling retardation and shelf life extension (Tong *et al*., 2010). This result was similar to as reported by Faller and Faller (2000) who mentioned that honey can be used to improve the shelf life of honey-flavored low-fat snacked chip products by keeping their moisture content and retarding the staling.

The firmness, represented by the peak force, illustrated in Fig. 2d show that firmness of the sucrose sponge cakes packed without and with O_2 absorber (T1 and T2) and both of the honey cakes (T3 and T4) during storage were 5.09 to 18.85 N and 4.48 to 16.88 N, respectively. It was noted that the sponge cake made with honey showed softer texture (low peak force) than that of the sucrose ($p<0.05$). This may be due to the total sucrose substitution by honey resulted in a higher viscosity of the batter, consequently promoting air bubbles retention which positively related to cake structure formation. Shelke *et al*. (1990) indicated that a high viscous batter supported air bubbles entrapment during baking, leading to a high volume in the sponge cake. Son and Lee (2011) showed a consistent result, namely sponge cakes with increasing tomato powder levels from 0 to 30% resulted in a decrease in specific volume, which was in consonance with a higher firmness. The firmness of all stored cakes increased ($p<0.05$) during storage. The increase in firmness is in agreement with Lee *et al*. (2008) who reported that the moisture losses from cake crumb caused a hardening of its crumb structure as a primary firming process. The secondary firming process included with starch retro gradation or moisture redistribution. The sucrose cake became harder than the honey cake after storage, which was related to the reduction in water activity as mentioned above.

Crumb color values which recorded for CIE L^* (lightness), a^* (redness) and b^* (yellowness) of all chocolate sponge cakes presented in Fig. 2 show that the honey cakes packed without and with O_2 absorber

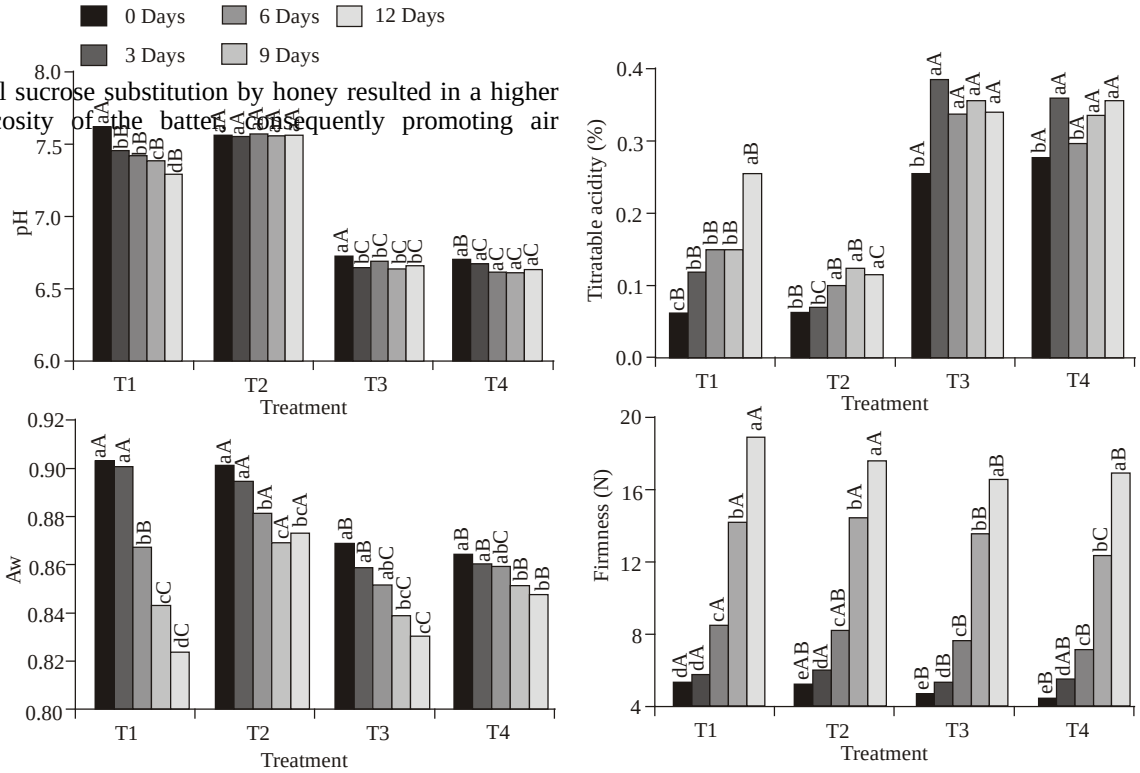

Fig. 1: Effect of honey and O_2 absorber on physicochemical properties of chocolate sponge cakes during storage at 30±2°C: (a) pH, (b) titratable acidity, (c) Aw and (d) firmness

[a, b, c, d, e]: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different storage times for the same sample; [A, B, C]: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different samples at the same storage time; Treatments: T1 = Sucrose sponge cake packed without O_2 absorber, T2 = Sucrose sponge cake packed with O_2 absorber, T3 = Honey sponge cake packed without O_2 absorber, T4 = Honey sponge cake packed with O_2 absorber

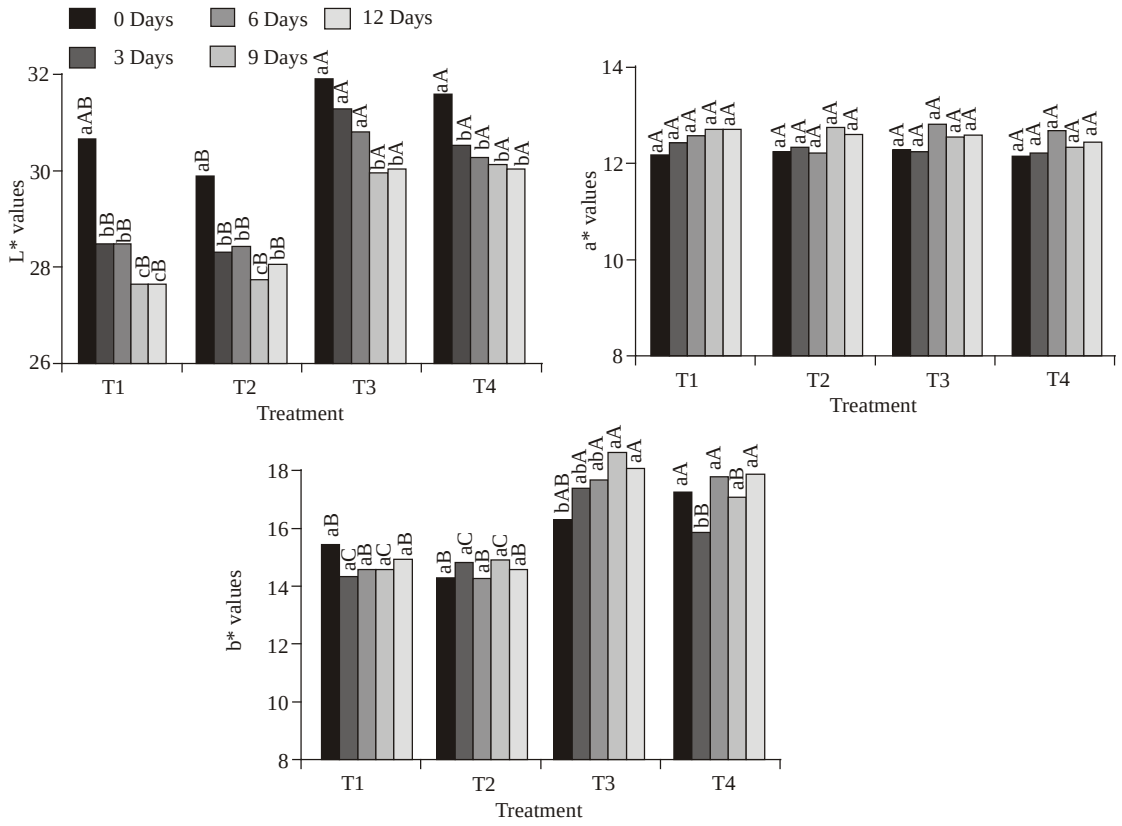

Fig. 2: Effect of honey and O_2 absorber on crumb color of chocolate sponge cakes, during storage at 30±2°C: (a) L* value, (b) a* value and (c) b* value

$^{a, b, c}$: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different storage times for the same sample; $^{A, B, C}$: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different samples at the same storage time; Treatments: T1 = Sucrose sponge cake packed without O_2 absorber, T2 = Sucrose sponge cake packed with O_2 absorber, T3 = Honey sponge cake packed without O_2 absorber and T4 = Honey sponge cake packed with O_2 absorber

Table 2: Effect of honey and O_2 absorber on microbiological analysis of chocolate sponge cakes during storage at 30±2°C

		Storage time (days)				
Microorganisms	Treatment	0	3	6	9	12
Mold	T1	-	-	+	+	+
	T2	-	-	-	-	-
	T3	-	-	-	-	-
	T4	-	-	-	-	-
Coliform	T1	-	-	-	-	-
	T2	-	-	-	-	-
	T3	-	-	-	-	-
	T4	-	-	-	-	-
Escherichia coli	T1	-	-	-	-	-
	T2	-	-	-	-	-
	T3	-	-	-	-	-
	T4	-	-	-	-	-

+: Growth; -: No growth; Treatments: T1 = Sucrose sponge cake packed without O_2 absorber, T2 = Sucrose sponge cake packed with O_2 absorber, T3 = honey sponge cake packed without O_2 absorber and T4 = Honey sponge cake packed with O_2 absorber

(T3 and T4) gave higher L^* values compared to both of the sucrose cakes (T1 and T2), indicating the honey cake with lighter color (Fig. 2a). This may be due to the addition of honey causes an increased amount of water in formulation, which dilutes the color of chocolate powder in this product. Also, there was a gradual decrease in L^* values ($p<0.05$) throughout the period of storage, this revealed that all stored cakes

became a little bit darker. The possible reason might be attributed to reducing sugars such as glucose and fructose can react with amino acids in the cake contributing to Maillard reaction (Tong *et al*., 2010). There were no significant differences ($p>0.05$) for a^* values among the cakes (Fig. 2b). The honey cake displayed higher b^* (more yellowish) values than the sucrose (Fig. 2c). This was attributed to the yellow color of honey itself. Furthermore, a^* and b^* values for all stored cakes did not significantly differ ($p>0.05$) during storage. These data suggested that the cake with added honey were lighter and more yellowish than the sucrose cake.

Microbiological analysis: In general, almost all market cakes are normally laid out on a shelf at room temperature rather than being stored in refrigerators. Undesirable microbial growth in cakes and other bakery products might occur, resulting in spoilage, especially when being stored at room temperature. The change in microbial flora of sponge cake as a function of treatment and storage time is shown in Table 2. The results show that the sucrose cake packed without O_2 absorber (T1) stored at room temperature (30±2°C) became moldy after the 6th day of storage, while the

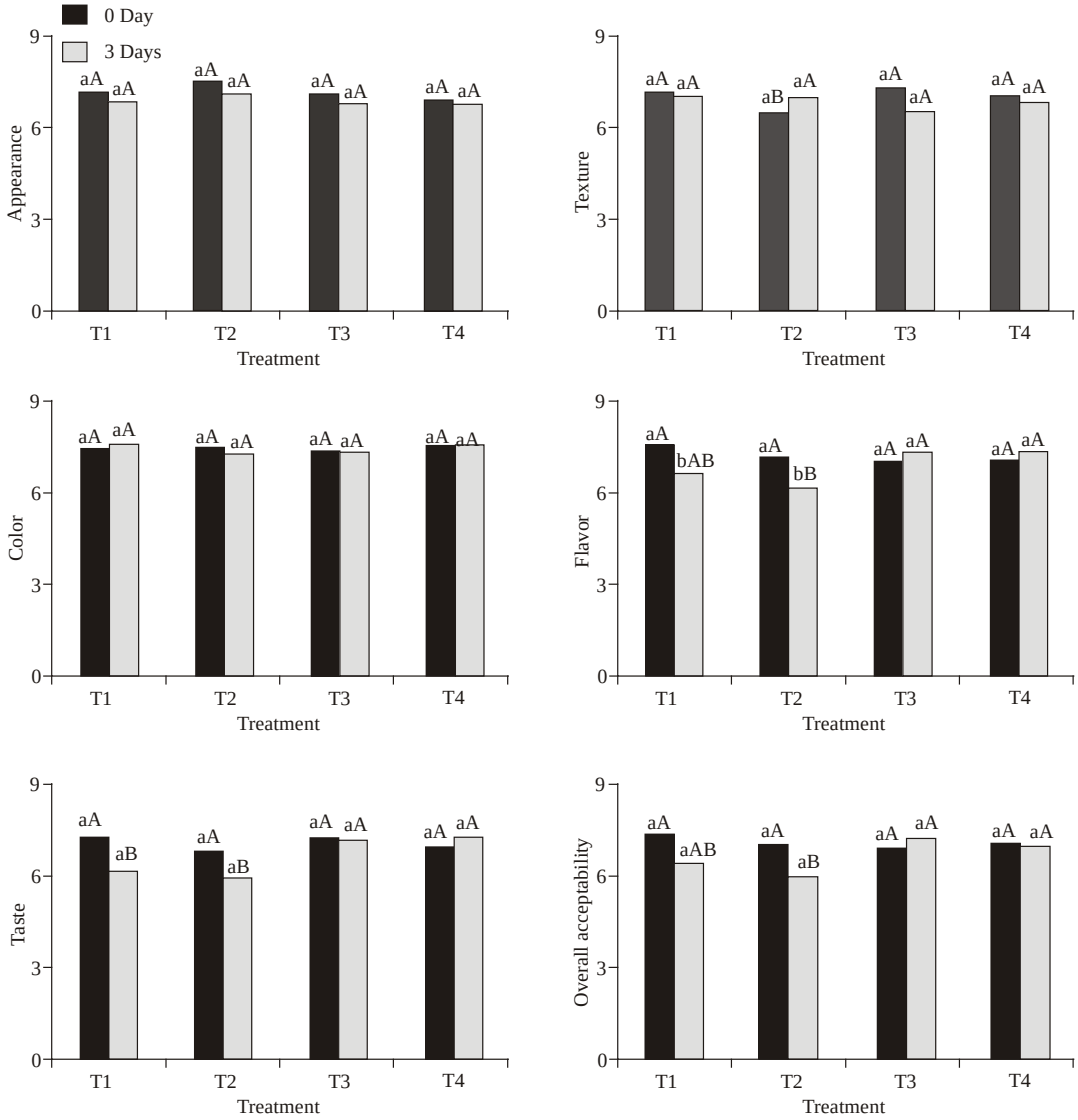

Fig. 3: Effect of honey and O_2 absorber on sensory attributes of chocolate sponge cake during storage at 30±2°C; (a) appearance, (b) texture, (c) color, (d) flavor , (e) taste and (f) overall acceptability
[a, b]: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different storage times for the same sample; [A, B]: Different superscript letters on the bar indicate significant differences ($p<0.05$) among different samples at the same storage time; Treatments: T1 = Sucrose sponge cake packed without O_2 absorber, T2 = Sucrose sponge cake packed with O_2 absorber, T3 = Honey sponge cake packed without O_2 absorber and T4 = Honey sponge cake packed with O_2 absorber

sucrose cake packed with O_2 absorber (T2) exhibited negative mold throughout storage time. This result revealed that a Wonderkeep® O_2 absorber acts by reducing oxygen concentration inside the package to the level below 0.1% in 24 h after packaging. It can reduce the oxygen in the package so the growth of aerobic microorganisms was inhibited, which was supported by the work of Smith *et al*. (1986) who reported that the oxygen absorbents were used effectively to inhibit growth of aerobic spoilage microorganisms, especially molds, in intermediate and high-moisture bakery products. There was no mold detected in the honey cakes packed without and with O_2 absorber (T3 and T4) throughout storage time. The results indicated that honey may be responsible for antimicrobial activities. Molan (1992) proposed that the high antimicrobial activity of honey is dependent on osmotic effect, acidity, hydrogen peroxide and phytochemical factors, which are believed to be many complex phenols and organic acids, often referred to as flavonoids. In addition, Coliform bacteria and *E. coli* counts were not detected in all stored cakes during storage period. The absence of Coliform bacteria and *E. coli* could be attributed to hygienic conditions during manufacture and packaging. Therefore, chocolate sponge cake prepared with honey could be stored for approximately 12 days at room temperature (30±2°C) as packed without O_2 absorber, whereas the sucrose cake was necessarily packed with O_2 absorber for extending the shelf life of the product.

Sensory evaluation: The results for sensory evaluation of chocolate sponge cake are presented in Fig. 3a to f. As visible mold growth found in the sucrose cake (T1) after the 6th day of storage, the sensory evaluation was done on the day 0 and 3 in this study based on the awareness for panelists' safety. Statistical analysis showed no significant difference ($p>0.05$) between the sucrose and honey cakes with regard to all sensory attributes at the zero time (day 0). Nevertheless, it was interesting to note that the sensory score of the cake which contained honey possessed a superior texture perception compared with the sucrose cake. Since honey is composed, to a large extent, of invert sugar, it is reasonable to associate with the ability of honey to retain moisture in cake crumb than the sucrose, thus resulting in more consumer preference.

After the 3rd day of storage, it was evident that all honey cakes packed with or without O_2 absorber showed no statistically significant differences ($p>0.05$) for all sensory attributes. Similar result was observed for the sucrose cake packed with or without O_2 absorber, in exception of the flavor score which was significantly decreased ($p<0.05$) after storage. This finding implies that a quality consistency of the honey cake could be received after processing until 3 days of storage by packaging without O_2 absorber. The result also revealed that, as compared sensory quality between sucrose and honey cakes after the 3rd day of storage, the panelist preferences on taste of the sucrose cakes with any packaging (T1 and T2) were significantly lower ($p<0.05$) than those containing honey.

CONCLUSION

Application of honey incorporated with O_2 absorber packaging was effective in extending the shelf life of chocolate sponge cake. Honey cake packed with or without O_2 absorber can be stored at room temperature (30±2°C) for 12 days with no mold growth. The O_2 absorber packaging was shown to provide beneficial in retarding mold spoilage in the sucrose cake up to 12 days in relation to that for 3 days storage as packed without O_2 absorber. From physicochemical analysis, values for pH, A_w and firmness of honey cakes were lower than those with sucrose, and the honey cakes also showed higher lightness and yellowness. The honey cakes displayed consistently good sensory quality after the 3rd day of storage. In future work, the role of type and quantity of honey on physical characteristics and eating quality of chocolate sponge cake will be investigated.

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REFERENCES

Adam, M.R. and M.O. Moss, 2000. Food Microbiology. 2nd Edn., Royal Society of Chemistry, Guildford.

AOAC, 1990. Official Method of Analysis. 15th Edn., Association of Official Analytical Chemists, Virginia, Washington D.C., pp: 805-845.

AOAC, 1998. Bacteriological Analytical Manual. 8th Edn., Association of Analytical Chemists, Gaithersburg, MD.

Cochran, W.G. and G.M. Cox, 1992. Experimental Design. 2nd Edn., John Wiley and Sons, New York.

Faller, J.F. and J.Y. Faller, 2000. Sensory and physical characteristics and storage stability of honey-flavored low-fat extruded chips. J. Food Qual., 23: 27-37.

Gutierrez, L., A. Escudero, R. Batlle and C. Nerin, 2009. Effect of mixed antimicrobial agents and

flavors in active packaging films. J. Agric. Food Chem., 57: 8564-8571.

Lawless, H.T. and H. Heymann, 1998. Sensory Evaluation of Food. Chapman and Hall, New York.

Lee, C.C., H.F. Wang and S.D. Lin, 2008. Effect of isomaltooligosaccharide syrup on quality characteristics of sponge cake. Cereal Chem., 85: 515-521.

Mexis, S.F., E. Chouliara and M.G. Kontominas, 2009. Combined effect of an O_2 absorber and oregano essential oil on shelf-life extension of Greek cod roe paste (Tarama Salad) stored at 4°C. Innov. Food Sci. Emerg. Technol., 10: 72-579.

Molan, P., 1992. The antibacterial activity of honey: The nature of antibacterial activity. Bee World, 73: 5-28.

Nagai, T., R. Inoue, N. Kanamori, N. Suzuki and T. Nagashima, 2006. Characterization of honey from different floral sources, its functional properties and effects of honey species on storage of meat. Food Chem., 97: 256-262.

Ouchemoukh, S., H. Lousileche and P. Schweitzer, 2007. Physicochemical characteristics and pollen spectrum of some Algerian honeys. Food Control, 18: 52-58.

Salminen, A., K. Latvia-Kala, K. Randell, E. Hurme, P. Linko and R. Ahvenainen, 1996. The effect of ethanol and oxygen absorption on the shelf-life of packaged slice rye bread. Package Technol. Sci., 9: 29-42.

Shelke, K., J.A. Fabien and R.C. Hosni, 1990. The dynamics of cake making as studied by a combination of viscometry and electrical resistance oven heating. Cereal Chem., 67: 575-580.

Smith, J.P., B. Ooraikul, W.J. Kerosene, E.D. Jackson and R.A. Lawrence, 1986. Novel approach to oxygen control in modified atmosphere packaging of bakery products. Food Micro., 3: 315-320.

Son, S.M. and J.H. Lee, 2011. Physicochemical qualities and consumer perception of tomato sponge cake. J. Food Sci. Nutri., 16: 390-393.

Tong, Q., X. Zhang, F. Wu, J. Tong, P. Zhang and J. Zhang, 2010. Effect of honey powder on dough archeology and bread quality. Food Res. Int., 43: 2284-2288.

Vermeiren, L., F. Devlieghere, M.V. Beest, N.D. Kruijf and J. Debevere, 1999. Developments in the active packaging of foods. Trends Food Sci. Technol., 10: 77-86.