

Research Article

## **Changes in physicochemical and textural properties of stuffed fish stick during storage**

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### **Abstract**

Physicochemical characteristics and textural properties of fish stick (FS) stuffed with two types of filling including seasoned-cooked carrot paste and spicy paste packed in polyethylene bags during storage at ambient temperature (25°C) for 4 weeks were investigated. Thiobarbituric acid reactive substances (TBARS) values of both stuffed FSs increased with increasing storage time ( $p < 0.05$ ). Generally, TBARS value of FS stuffed with spicy paste was higher than that of FS stuffed with seasoned-cooked carrot paste within 3 weeks. However, no differences in TBARS values in both products were observed at the end of storage period ( $p > 0.05$ ). The moisture content of both stuffed FSs decreased sharply during the first week of storage ( $p < 0.05$ ) and gradually decreased till the end of storage. The  $L^*$  value of both stuffed FSs decreased within the first 2 weeks of storage ( $p < 0.05$ ) and tended to increase throughout the storage time. The  $a^*$  and  $b^*$  values of FS stuffed with seasoned-cooked carrot paste were higher than those of FS stuffed with spicy paste throughout the storage period. The  $a^*$  value of both products was remained unchanged with increasing storage time ( $p > 0.05$ ). However, the  $b^*$  value of both products tended to decrease within the first 2 weeks and tended to increase until the end of storage period. The increase in hardness with the decrease in springiness, cohesiveness and adhesiveness during storage was noticeable in both products ( $p < 0.05$ ).

**Keywords:** seafood, storage, surimi, physicochemical, textural properties, Thailand.

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### **Introduction**

Fish stick (FS), one of the ready-to-eat snacks and is well accepted in Thailand. In general, FS is made from fish meat or surimi with flour and some seasonings and cooked with a drum dryer or an extrusion unit [1]. After drying, the product is fried or roasted to yield the individual color, cut into thin-long pieces and packed in polyethylene bag. The commercial FSs available in recent market are different only in flavor added [2]. The development of FS was conducted

by stuffing a variety of fillings into FS [2]. Panpipat and Chaijan [3] studied the physicochemical properties and acceptability of stuffed FS prepared with different fillings including seasoned-cooked pumpkin paste, seasoned-cooked carrot paste, seasoned-cooked potato paste, spicy paste (stirred-fried chili paste) and cheese. The sensory characteristics of stuffed FS were associated with their physicochemical properties and those were governed by the type of fillings used. Panpipat and Chaijan [3] also concluded that the stuffed FS filled with spicy paste and seasoned-cooked carrot paste showed the highest score of acceptability which was in the scale of like moderately. However, the addition of filling into the FS might render the characteristics as well as the storage stability of FS. Generally, the fillings formulated for the fish stick contained some vegetable oil which can cause the oxidative instability of the final products. In the present study, fish stick products were made from mackerel which is a fatty fish. These fatty fish products may undergo rapid lipid oxidation during storage due to their high content of polyunsaturated fatty acids [4]. Apart from lipid oxidation, discolouration and protein denaturation and/or aggregation are major problems generally faced in stored fish products [5, 6, 7]. Those changes may occur in a concurrent manner and each process might appear to enhance the other. Therefore, the objective of this study was to evaluate the physicochemical characteristics and textural properties of stuffed FS during storage.

## Materials and Methods

### Materials

FS was produced by mixing the 75% of surimi with 25% of mixed ingredients (6.6% of wheat flour, 15.4% of tapioca flour, 2% of salt and 1% of sugar). The mixture was chopped for 5 min to obtain the homogeneous paste. The paste was then stuffed into a plastic bag and subject to spread by using a drum drier with a 3 mm aperture at a speed of 1 rpm at room temperature. The sheet obtained was steamed at 100°C for 30 min and dried at 65°C for 45 min using a tray drier. Thereafter, the filling was stuffed between two layers of sheets. Two types of filling including seasoned-cooked carrot paste and spicy paste (stirred-fried chili paste) were selected [3]. The seasoned-cooked carrot paste composed of 83.3% of boiled ground carrot and 16.7% of stirred-fried chili paste. For the ingredients used for spicy paste preparation, it contained 73.5% of stirred-fried chili paste, 15.4% of tamarind juice, 4.4% of wheat flour, 4.4% of ground onion and 2.2% of soybean oil. The filling pastes were prepared by stirred-frying all ingredients until the  $a_w$  of the mixture reached 0.7-0.8. After stuffing, the stuffed FS was baked for 10 min at 140°C using an oven. After cooling down, the baked stuffed FS was cut into a thin-long piece with the size of 1×10 cm<sup>2</sup> which was referred to as 'stuffed FS'. The stuffed FS was packed in polyethylene bags and subjected to storage at ambient temperature (25°C) for 4 weeks. During storage the samples were randomly taken at week 0, 1, 2, 3 and 4 for analyses. The analyses were performed for TBARS, moisture content, color ( $L^*$ ,  $a^*$  and  $b^*$  values) and textural properties including hardness, springiness, adhesiveness and cohesiveness.

### Methods

#### Determination of TBARS

TBARS assay was performed as described by Buege and Aust [8]. Sample (0.5 g) was homogenized with 2.5 ml of a solution containing 0.375% thiobarbituric acid, 15% trichloroacetic acid and 0.25 N HCl using an IKA Labortechnik homogenizer (Selangor, Malaysia). The mixture was heated in a boiling water bath (95-100°C) for 10 min to develop a pink color, cooled with running tap water and centrifuged at 3,600×g at 25°C for 20 min using a RC-5B plus centrifuge (Sorvall, Norwalk, CT, USA). The absorbance of the supernatant was measured at 532 nm. A standard curve was prepared using 1,1,3,3-tetramethoxypropane at

concentrations ranging from 0 to 10 ppm. TBARS was calculated and expressed as mg malonaldehyde/kg sample.

#### *Determination of moisture content*

Moisture content of stuffed FS was determined according to the method of AOAC [9].

#### *Determination of colour*

The surface colour of the composite stuffed FS sample previously cut into small pieces was determined by measuring L\* (lightness), a\* (+red to -green component) and b\* (+yellow to -blue component) values using a colorimeter (Juki Corp, Tokyo, Japan). Samples were placed and filled into a 5-cm diameter glass petri dish and illuminated with D65-artificial daylight (10° standard angle).

#### *Texture measurement*

Texture profile analysis was performed using a TA-XT2i texture analyzer (Stable Micro Systems, Godalming, Surrey, UK), equipped with a Warner-Bratzler blade (60° knife edge blade). The blade was pressed down at a constant speed of 2 mm/s through the sample. Maximum shear force and work needed to cut the sample were recorded. Hardness, adhesiveness, springiness, and cohesiveness were calculated from the force-time curves generated for each sample [10].

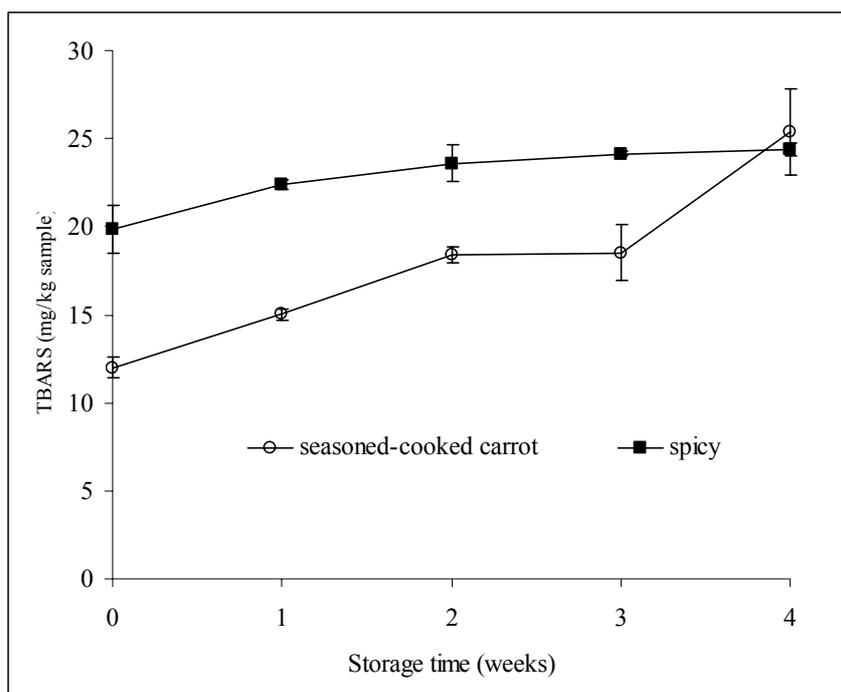
#### *Statistical analysis*

Data were subjected to analysis of variance (ANOVA). Comparison of means was carried out by Duncan's multiple-range test [11]. Statistical analysis was performed using the Statistical Package for Social Science (SPSS 8.0 for windows, SPSS Inc., Chicago, IL).

## **Results and Discussion**

### ***Changes in TBARS***

Changes in TBARS values of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks are shown in Fig. 1. The result showed that TBARS values of both stuffed FSs increased with increasing storage time ( $p < 0.05$ ) indicating the oxidation of lipid in both samples. The increase in TBARS indicated formation of secondary lipid oxidation products [12]. TBARS has been used to measure the concentration of relatively polar secondary reaction products, especially aldehydes [13]. The higher rate of lipid oxidation as measured by TBARS value was observed in FS stuffed with spicy paste during the first 3 weeks of storage ( $p < 0.05$ ) but no differences in TBARS in both samples were noticeable at week 4 of storage ( $p > 0.05$ ). The higher extent of lipid oxidation in FS stuffed with spicy paste was possibly due to the higher content of oil deposited in the spicy paste when compared with seasoned-cooked carrot paste. In addition, stirred fried chili paste (named spicy paste) was initially heated for a period of time during processing. This might result in the formation of partially oxidized lipid. The oxidized lipids with their oxidation products probably resulted in the induced oxidation of non-oxidized lipid during stuffed FS processing and storage. From the result, the rate of lipid oxidation in FS stuffed with seasoned-cooked carrot paste was lower than that in FS stuffed with spicy paste ( $p < 0.05$ ). This was probably due to the chemical composition found in carrot matrix especially carotenoid which exhibited the antioxidant activity. From the result, the oxidation of lipid in FS stuffed with seasoned-cooked carrot paste increased continuously during storage and it was marked increased at the end of storage period ( $p < 0.05$ ). This might be due to the degradation of natural antioxidants found in carrot.

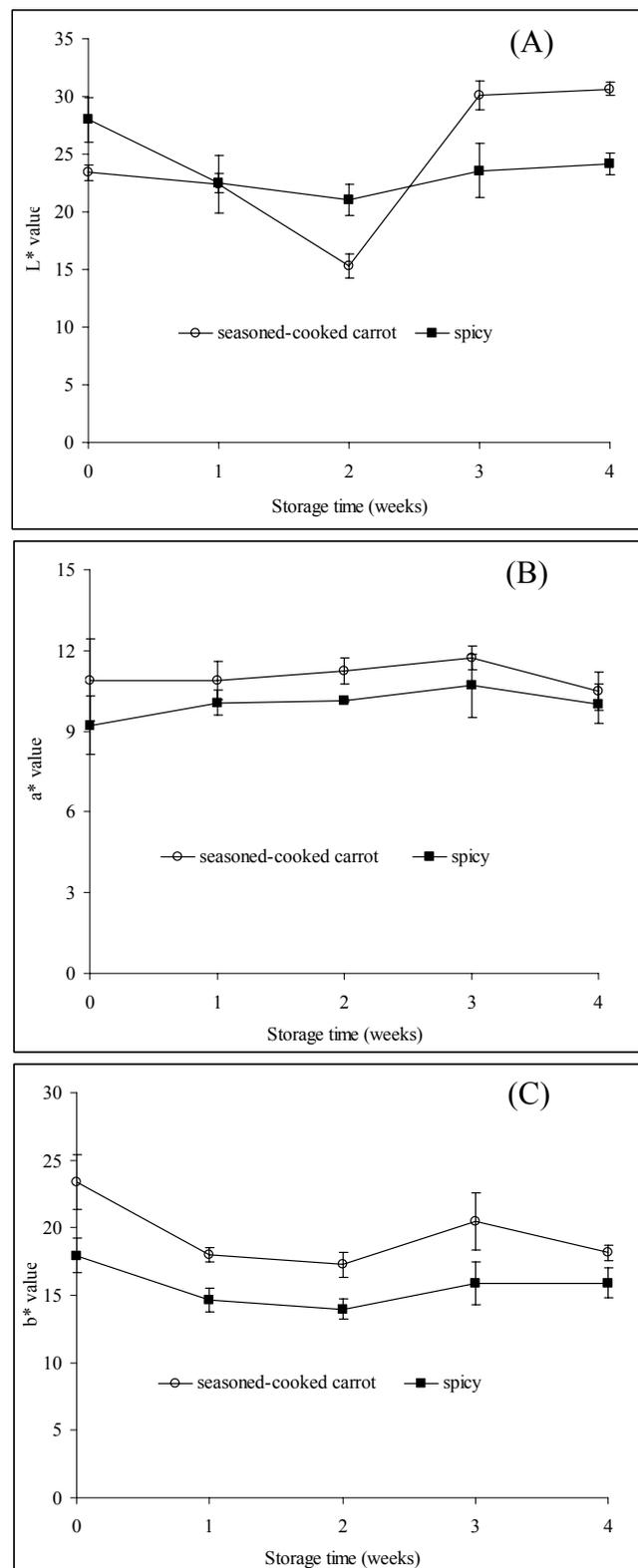


**Figure 1. Changes in TBARS value of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks.**

Values are given as mean  $\pm$  SD from triplicate determinations.

### **Changes in colour**

Changes in colour of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks are depicted in Fig. 2.  $L^*$  value of FS stuffed with spicy paste decreased within the first week of storage ( $p < 0.05$ ) and remained unchanged till the end of storage period ( $p > 0.05$ ) (Fig. 2A). For FS stuffed with seasoned-cooked carrot paste,  $L^*$  value decreased within the first 2 weeks of storage ( $p < 0.05$ ; Fig. 2A). Thereafter, it continued to increase in week 3 ( $p < 0.05$ ) and remained constant until the end of storage period ( $p > 0.05$ ). Changes in  $a^*$  values of stuffed FS during storage are shown in Fig. 2B. The  $a^*$  value of FS stuffed with seasoned-cooked carrot paste was generally higher than that stuffed with spicy paste throughout the storage time ( $p < 0.05$ ). This might be due to the original colour of carrot which was orange to red. The fish stick sheet might partially allow some light to penetrate through the sheet and the pigment or coloured compounds inside the filling can reflect the light to the surface. Thus, the surface colour of the stuffed fish stick was affected by filling used. The  $a^*$  value of FS stuffed with both fillings remained unchanged during the storage period ( $p > 0.05$ ). For  $b^*$  value (Fig. 2C), it was noted that FS stuffed with seasoned-cooked carrot had a higher  $b^*$  value than that stuffed with spicy paste throughout the storage period ( $p < 0.05$ ). This was also due to the natural colour of carrot. With increasing storage time,  $b^*$  values of both samples tended to decrease within the first 2 weeks and tended to increase in the later stage of storage. This might be due to the occurrence of some discolouration induced-chemical reactions such as the oxidation and/or degradation of carotenoid in carrot or the pale discolouration of pigment in chili. However, the increase in  $b^*$  value was noticeable with increasing storage time. This might be caused by the products derived from Maillard reaction. Chaijan *et al.* [14] reported that aldehydes or carbonyl compounds produced from lipid oxidation can interact with protein amino groups via Maillard reactions.

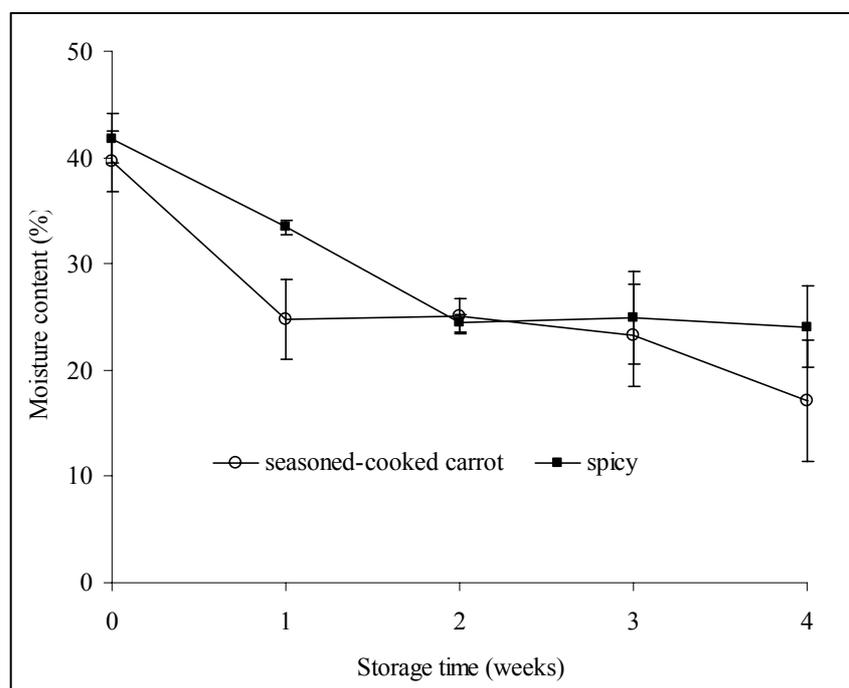


**Figure 2. Changes in L\* (A), a\* (B) and b\* (C) values of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks.**

Values are given as mean ± SD from triplicate determinations.

### ***Changes in moisture content***

The moisture content of both stuffed FSs decreased sharply during the first week of storage ( $p < 0.05$ ) and gradually decreased till the end of storage (Fig. 3). The decrease in moisture content was probably due to the loss of moisture during storage caused by evaporation. The loss of water might associate with the changes in textural properties of stuffed FS. Different moisture loss suggested the difference in water holding capacity of protein network in the product [15]. From the result, the moisture reduction was found at a higher rate in FS stuffed with seasoned-cooked carrot paste when compared with that stuffed with spicy paste. This might be due to the difference in water holding capacity of chemical components composed in fillings. From the result, carrot flesh used for filling production might contain a lower water holding capacity than spicy paste. In addition, spicy paste composed of a higher content of lipid. Therefore, lipid might act as a barrier to prevent the water loss during storage.



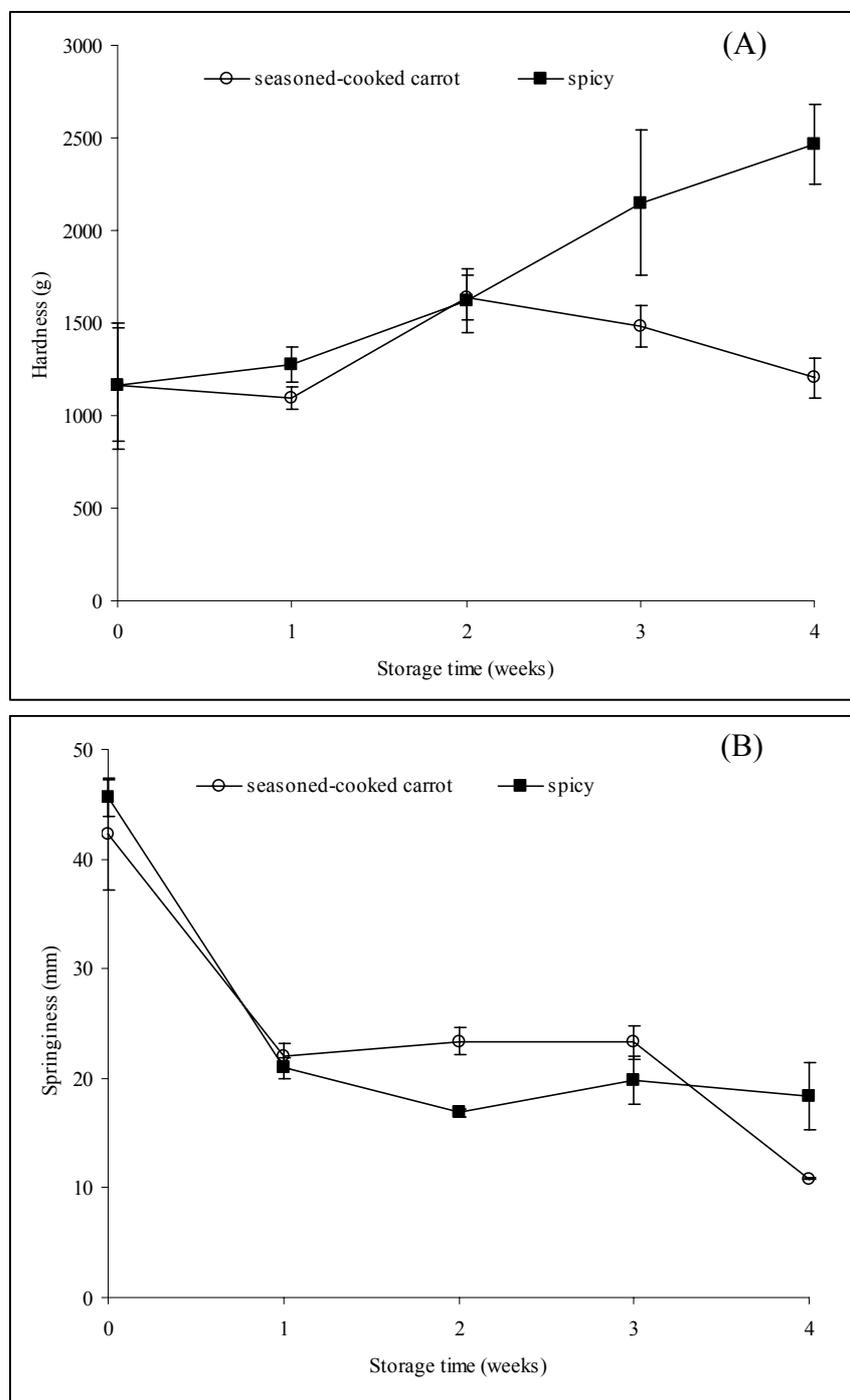
**Figure 3. Changes in moisture content of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks.**

Values are given as mean  $\pm$  SD from triplicate determinations.

### ***Changes in textural properties***

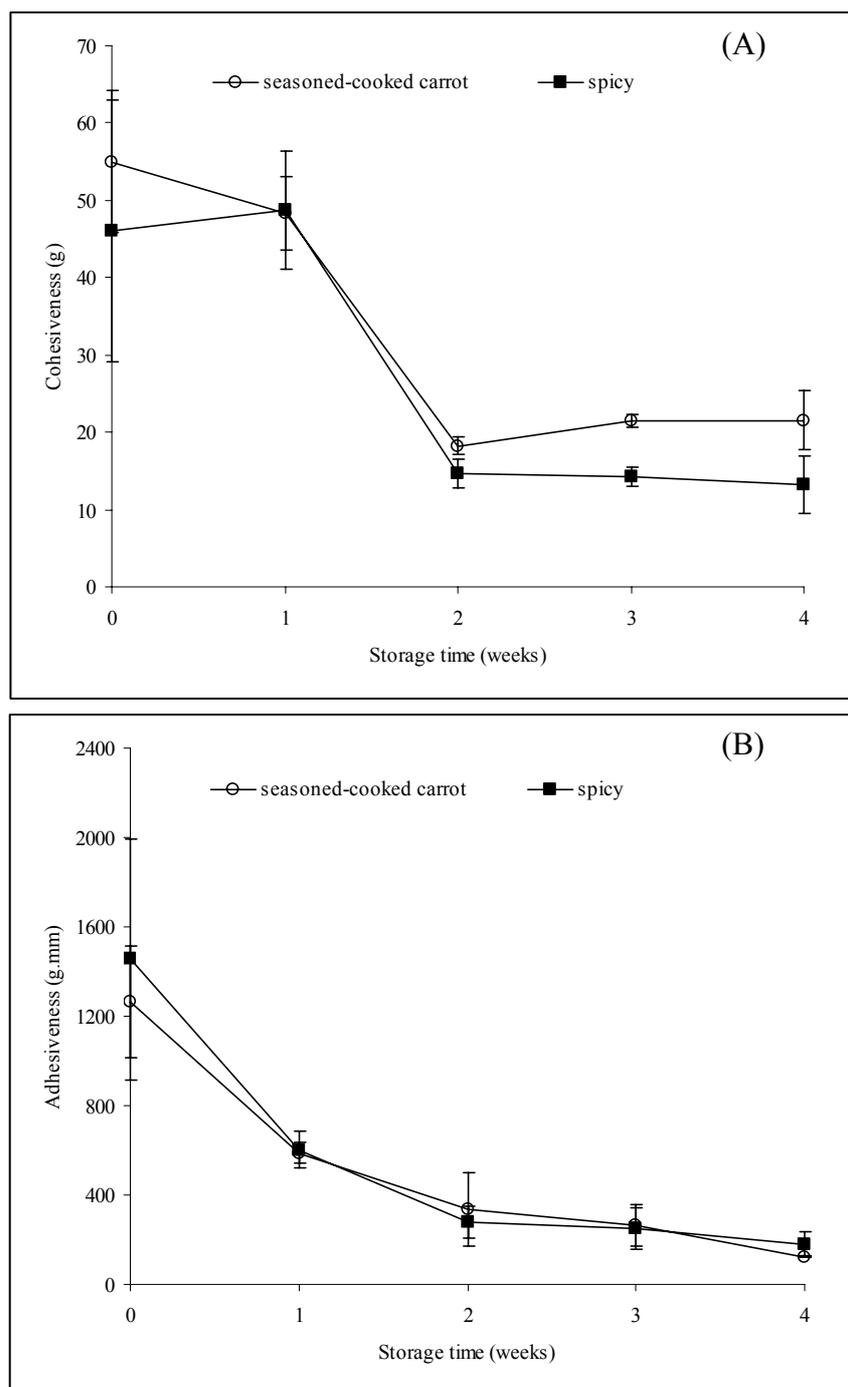
Changes in textural properties including hardness, springiness, cohesiveness and adhesiveness of FS stuffed with different fillings during storage are shown in Fig 4(A), 4(B), 5(A) and 5(B), respectively. From the results, the increase in hardness with the decrease in springiness, cohesiveness and adhesiveness during storage was found in both samples. These changes were in accordance with the decrease in moisture content (Fig. 3). The results suggested that both stuffed FSs tended to fracture during storage. From the result, FS stuffed with spicy paste tended to have a higher hardness than that stuffed with seasoned-cooked carrot throughout the storage period. This was in agreement with the higher rate of lipid oxidation (Fig. 1) found in this sample. The lipid oxidation yielded a variety of products in which aldehyde was a major product. The formation of aldehyde might induce the cross-linking and/or aggregation of proteins in stuffed FS and might cause the separation of aggregated proteins from starch network. These changes thus might result in the increase in hardness and fracturability of FS

stuffed with spicy paste. Lipid oxidation generates a wide range of secondary aldehyde products including *n*-alkanals, *trans*-2-alkanals, 4-hydroxy-*trans*-2-alkanals and malonaldehyde [16]. Secondary products from lipid oxidation, especially aldehydes, can induce myofibrillar protein cross-linking, resulting in structural and functional changes in these proteins [17, 18].



**Figure 4. Changes in hardness (A) and springiness (B) of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks.**

Values are given as mean  $\pm$  SD from five determinations.



**Figure 5. Changes in cohesiveness (A) and adhesiveness (B) of FS stuffed with seasoned-cooked carrot paste and spicy paste during storage in polyethylene bag at room temperature (25°C) for 4 weeks.**

Values are given as mean  $\pm$  SD from five determinations.

## Conclusion

The changes in physicochemical and textural properties of FS stuffed with seasoned-cooked carrot paste and spicy paste demonstrated the same trend. The increase in lipid oxidation with the decrease in moisture content was observed during extended storage. These changes coincided with the changes in colour and texture of stuffed FS.

## Acknowledgments

The authors would like to express their sincere thanks to the Commission of Higher Education of Thailand for financial support.

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