

Research Paper

Process improvement for Thai-style fried rice crackers

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Abstract: The quality of Thai-style fried rice crackers depends on the efficiency of the production process, including molding, drying, moisture retention, type of frying oil, frying temperature and frying time. Multiple molds were studied and it was found that thickness of the mold affected the product quality and the time involved in molding. Using a 2.5 cm diameter mold gave the best result at 0.5 cm thickness, while a 4.0 cm diameter mold provided the best result at 0.8 cm thickness. Drying at 65°C with moisture content at 10% gave the best result for crispiness, oil uptake and the least chemical change in the frying oil. Frying temperatures and frying times showed that frying rice crackers with palm olein oil at temperature 210°C for 30 seconds gave the most brightness, the least oil uptake of the product and the least chemical change of frying oil. TBHQ (tert-Butyl Hydroquinone), BHA (Butylated Hydroxyanisole) with BHT (Butylated Hydroxytoluene) and Pandan leaves were used as antioxidants to decrease deterioration of the product and frying oil. It was found that TBHQ provided the least product oxidation during storage of 60 days as well as the least frying oil oxidation.

Keywords: food processing, TBHQ, antioxidants, oxidation, snacks, oil, frying

Introduction

Thai-style fried rice crackers are a common Thai snack food, referred to locally as *nang led* or *kawtan*. It is made from whole grains of glutinous rice as a patty with crispy texture being the main characteristic. The Sansailuang Farmers' Housewife Group (SFHG) have traditionally made these crackers for many years and are now facing a number of problems due to higher demand. These problems are due to low efficiency of molding process, no sunlight for drying in the rainy season and low storage life as the product quality degrades within a short time. These problems have been addressed by a number of research projects in cooperation with the SFHG, including the search for a more efficient mold. Studies on

the drying process using a cabinet dryer and studies on the frying process have been undertaken. Saiai and Chaithep (2004) designed a cabinet dryer for drying rice crackers, suggesting a temperature of 50-70°C until the moisture content is lower than 15%. Bouchon *et al.* (2003) studied oil absorption during frying and concluded that potato chips absorbed maximum oil during cooling. Math *et al.* (2004) reported about frying *papad* and concluded that frying at higher temperatures resulted in higher oil uptake. Also deterioration of oil during frying results in a higher degree of unsaturated oil and longer frying time (Naz *et al.*, 2005). It has been found that antioxidants can retard oxidation in oil (Reisehe, 2002). Pandan leaves (*Pandanus amaryllifolius*) are one of the natural sources of antioxidants (Rakariyathum and Janwiti, 2002, Ling and Suhaila, 2001) and are frequently used in South East Asian cuisine.

Materials and Methods

Materials

Glutinous rice of *Kowkor 6* variety, watermelon juice of *Kinaree* variety, salt, white and black sesame seeds, palm kernel and coconut oil mixed in a ratio 2:1 (Twin Chinese Cabbages trade mark) and palm olein oil (Flower trade mark) were purchased from a local market in Chiang Mai. Acrylic plastic molds (chemical and heat resistant), a cabinet dryer (Termark: TS 747 model, Norway), were used, along with synthetic antioxidants, TBHQ, BHA and BHT (Fluka: Sigma-aldrich, USA). Natural Pandan leaves were purchased from a local market.

Preparing ingredients for molding

The glutinous rice was soaked in water for at least 6 hours and then steamed until the grain is soft. The cooked glutinous rice (96.3%) and other ingredients, watermelon juice (2.2%), salt (0.5%), white and black sesame seed (0.5% each) were all mixed thoroughly and molded while still warm.

Molding process

Multiple molds were designed employing 2 diameters. The smaller size with diameter 2.5 cm was studied for 3 sizes of product thickness 0.4, 0.5 and 0.6 cm. The larger size with diameter 4.0 cm was studied for 3 sizes of thickness 0.6, 0.8 and 1.0 cm. The actual molding process was undertaken by the SFHG, comparing the designed molds with the traditional model. The efficiency was measured by checking the number of pieces produced within 1 hour, the number of crackers retaining their shape after removing from the mold, the number of pieces broken after frying and the number of pieces required to fit to the bag size 8.75×6 inches for small crackers and 8×12 inches for large crackers. The results were analyzed for variances of means by using completely random design (CRD). The differences of means were analyzed by New Duncan multiple designed range test (DMRT) with SPSS version 15.

Drying process

The optimal thickness of the larger size mold was used to made crackers for this study. After molding the crackers were dried for 3 levels of treatment; 60, 65, and 70°C, drying until the moisture contents were about 5, 10 and 15% at each drying temperature. After

finding the optimum temperature and moisture retention, the crackers were then fried in mixed oil, using the same oil utilized by the SFHG.

Frying process

The frying temperature was set at 200°C for 45 seconds (same conditions as the SFHG). Before and after frying the oil was sampled for free fatty acid (FFA) and Thiobarbituric acid reactive substance (TBARS) analysis. The crackers were analyzed for oil absorption, number of broken pieces by counting and texture analysis. Texture analysis measured minimum force to break crackers by using universal testing machine with ball probe 0.5 cm diameter, load cell of 5 kilograms and 20 mm/sec test speed (TA.XT plus model, UK). Oil absorption analysis was done by Soxhlet method (AOAC, 2000) with the modification of using a Soxhtech apparatus (Soxtec system HT6 1043, Extraction Unit model, Sweden). FFA analysis was done by AOCS method Ca 5a-40 (2006) and TBARS analysis was done by AOCS official method Cd 19-90 (2006). Data were analyzed by using 3×3 factorial in CRD for variance of means. The differences of means were analyzed by DMRT with SPSS version 15.

The frying of crackers was then compared using mixed oil and palm olein oil. Frying was performed using each oil at 200, 210 and 220°C for 30, 40 and 50 seconds at each temperature compared with the frying process of the SFHG (200°C and 45 seconds). Samples dried by the optimum process were used for frying. The optimum frying oil, frying temperature and frying time were analyzed for the least change to the frying oil and the properties of crackers. The least change to oil quality was analyzed by determining the increased amount of conjugated dienes (CD) by Brown and Snyders method as stated in Pegg (2005) and TBARS. The properties of crackers were analyzed for colour in CIE system (Tri-Stimulus Colorimeter Model JC801) and oil absorption. The data were analyzed by using 2×3×3 factorial in CRD + Control. The differences of means were analyzed by DMRT with SPSS version 15.

Antioxidants study

The optimal type of frying oil, frying temperature and frying time were determined and then the natural and synthetic antioxidants were added to the oil before frying the crackers. Types and rates of antioxidants used were TBHQ 200 ppm, BHA with BHT 100 ppm each and Pandan leaves 20 g per 6 litres of oil. These treatments were also compared with no use of antioxidants. The optimal antioxidant was analyzed by measuring quality of oil extracted from the crackers with a chloroform/methanol (2:1) mixture (Rafecas *et al.*, 1998). These qualities were peroxide value (PV) (AOCS, 2006) and TBARS for storage time at 15, 30, 45, 60, 75 and 90 days. Sensory evaluation of the crackers was undertaken using the Quantitative Descriptive Analysis (QDA) method with ten trained panelists. The data were analyzed by using 4×7 factorial in CRD for variances of means. The differences of means were analyzed by DMRT with SPSS version 15.

Results and Discussion

Molding process

The results in Table 1 show that the optimal mold of the smaller size is the one with 0.5 cm thickness. It showed the lowest number of pieces broken after frying and the number of pieces fitting the packaging bag close to the control. The optimal mold of the larger size is the one with

0.8 cm thickness. It showed the best tendency for retaining its shape after removal from the mold and the number of pieces fitting the packaging close to the control. Both of these optimal molds had a higher production rate than the control.

Table 1. Molding efficiency and fried rice crackers properties from various size molds.

Testing items	Mold thickness (cm)			
	Control (0.50)	0.40	0.50	0.60
1. small mold				
1.1 production rate (pieces/hour)	384.11 ^c ±13.42	614.45 ^{ab} ±10.55	555.13 ^b ±58.33	656.89 ^a ±50.46
1.2 number of pieces in mold shape after mold removing (%)	100.00	95.83±3.61	98.33±1.81	98.75±1.25
1.3 number of pieces broken after frying (%)	4.94±0.32	4.68±0.75	3.95±1.06	4.55±0.32
1.4 number of pieces fit to the bag size 8.75×6 inch (pieces)	29.00 ^b	34.67 ^a ±0.50	29.00 ^b	25.78 ^c ±0.44
mold thickness (cm)	Control (1.00)	0.60	0.80	1.00
2. large mold				
2.1 production rate (pieces/hour)	297.10 ^b	425.71 ^a	424.51 ^a	429.45 ^a
2.2 number of pieces in mold shape after mold removing (%)	100.00	99.33±1.15	100.00	99.33±1.15
2.3 number of pieces broken after frying (%)	5.01 ^a ±0.05	3.60 ^b ±0.05	3.63 ^b ±0.18	2.49 ^c ±0.66
2.4 number of pieces fit to the bag size 8×12 inch (pieces)	29.22 ^b ±0.44	33.78 ^a ±0.44	28.56 ^b ±0.53	24.78 ^c ±0.44

Note: ^{a-c} Averages in the same row within the same data (category) that are not followed by the same superscript letter are significantly different ($P < 0.05$). Values are average of three replications.

Drying process

An examination of the drying temperatures and the remaining moisture found that drying rice crackers to 15% moisture retention had a water activity range of 0.84-0.85, as shown in Table 2. This presents the risk of the growth of fungi on the crackers surface and it is not suited to keeping dried crackers at room temperature. Conversely, drying at three temperature levels to obtain crackers with 5% remaining moisture was found to be unsuitable for frying because they were broken more easily and retained a darker colour than that found with the other moistures, as shown in Figure 1. Breakage was found to be due to the adhesion force between rice grains of the dryer samples and the dark colour is due to maillard reaction. The rate of maillard reaction increases as the moisture content of reactants decrease. The fried rice crackers obtained from drying at 65°C with 10% remaining moisture had lower hardness values (Figure 3), which resulted in better crispiness than other drying temperatures with the same remaining moisture content. Figures 5 and 6 confirm that drying at 65°C to obtain a remaining moisture content of 10% is the best due to the lower increase free fatty acids (FFA) and TBARS when compared with the same moisture content of other drying temperatures. Oil absorption, as shown in Figure 4, is due to vaporization of moisture in the crackers during frying.

Vaporization causes cavities and bigger cavities can carry more oil, while also giving crisper crackers. FFA are liberated from oil during frying due to hydrolysis of triglycerides accelerated by moisture and heat. FFA are then further decomposed by lipid oxidation. Final products of oxidation are volatile compounds such as aldehydes, ketones, and organic acid non-volatile compounds of higher molecular weight hydrocarbon. TBARS is used to measure aldehydes of highly unsaturated lipids.

Table 2. Drying rate of dried rice crackers by hot air oven drying.

Testing	Drying rate								
	60°C			65°C			70°C		
Drying temperature									
Remaining moisture	5%	10%	15%	5%	10%	15%	5%	10%	15%
Drying time (hr)	20.32	4.00	2.50	7.30	2.18	1.37	4.22	1.40	1.03
Water activity	0.40	0.63	0.85	0.35	0.58	0.84	0.37	0.57	0.85

Note: Drying times and water activity values are an average of three replications.

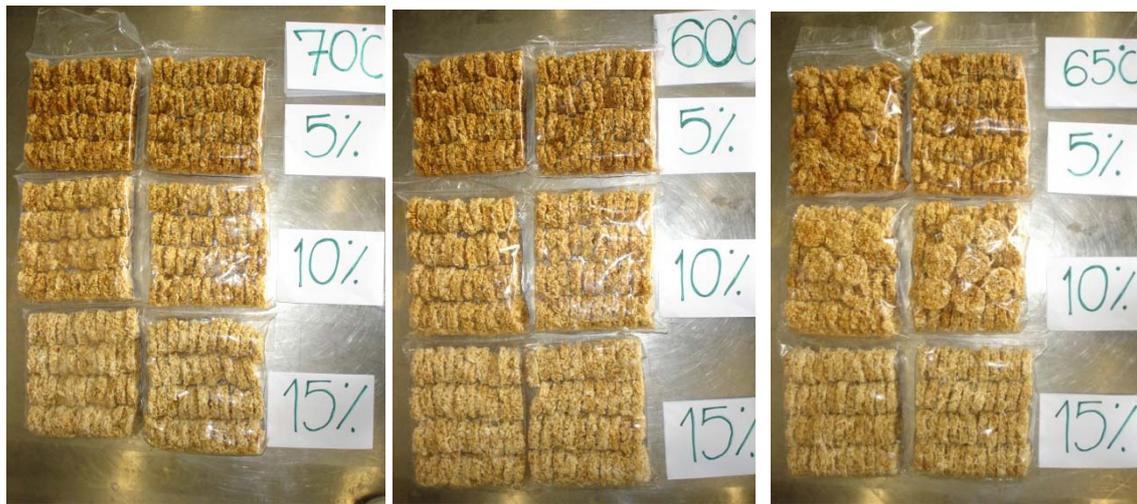


Figure 1. Effect of drying temperature and remaining moisture on colour of fried rice crackers.

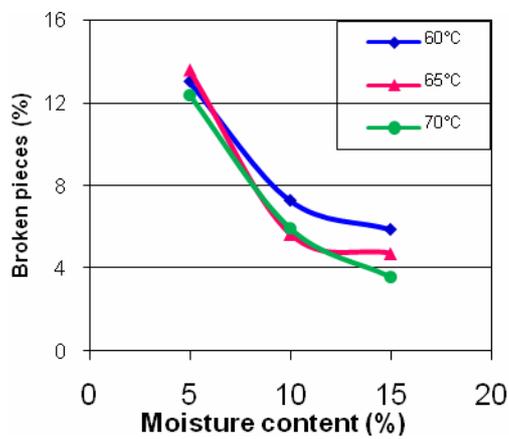


Figure 2. Effect of drying temperature and remaining moisture on number of pieces broken after frying.

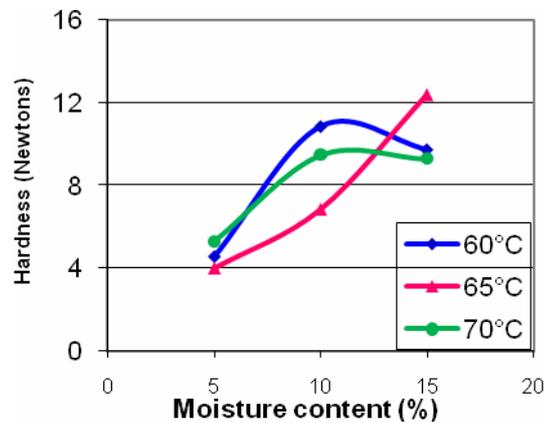


Figure 3. Effect of drying temperature and remaining moisture on hardness of crackers.

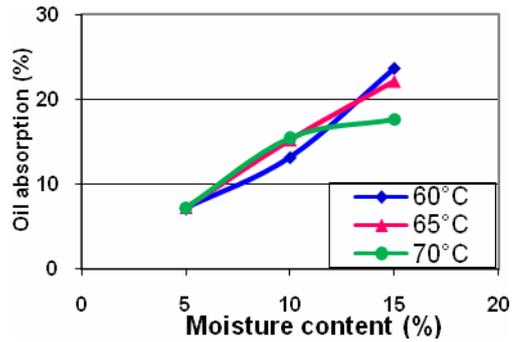


Figure 4. Effect of drying temperature and remaining moisture on oil absorption of crackers.

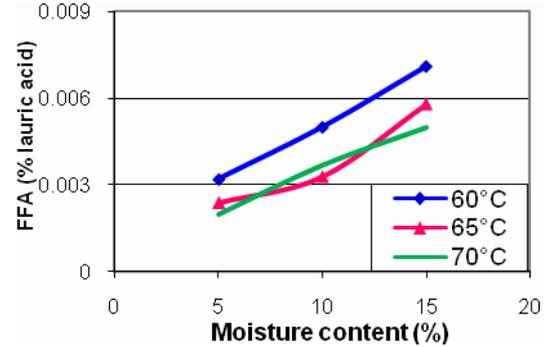


Figure 5. Effect of drying temperature and remaining moisture on the increased amount of FFA in oil after frying crackers.

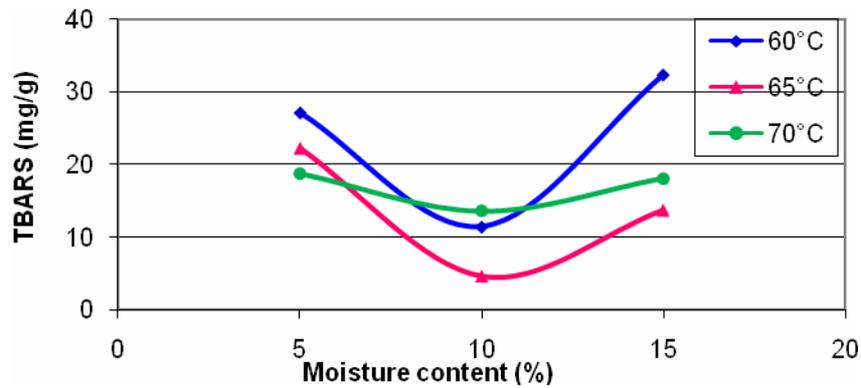


Figure 6. Effect of drying temperature and remaining moisture on the increased amount of TBARS in oil after frying crackers.

Frying process

Rice crackers of 0.8 cm thickness and 4.0 cm diameter, dried at 65°C to obtain 10% remaining moisture by cabinet dryer were used in this experiment. The result of experimenting with frying oil types, frying temperatures and times found that the optimal L* values were at 24-26 scales as shown in Figure 7. The crackers were golden colour. If the L* value is lower than 24, they had dark-brown colour. However, if it was higher than 26, they had pale colour and the trained panelists refused these fried rice crackers. The optimal conditions were using palm olein oil and frying at 210°C for 30 seconds. This treatment shows moderate oil absorption as shown in Figure 8.

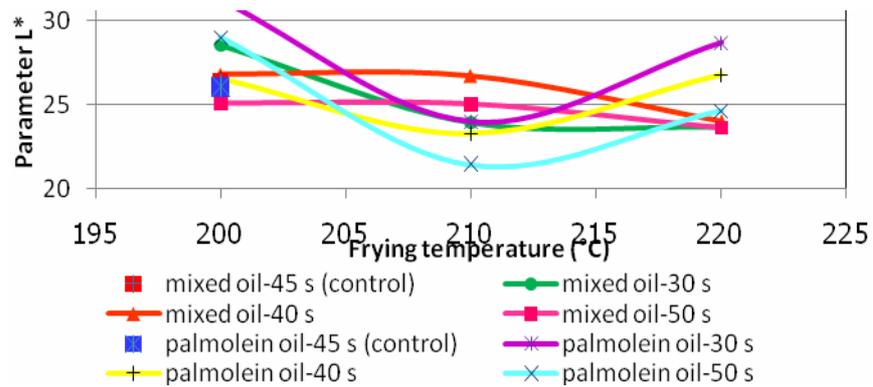


Figure 7. Effect of oil types, frying temperatures and frying times on L* value of crackers.

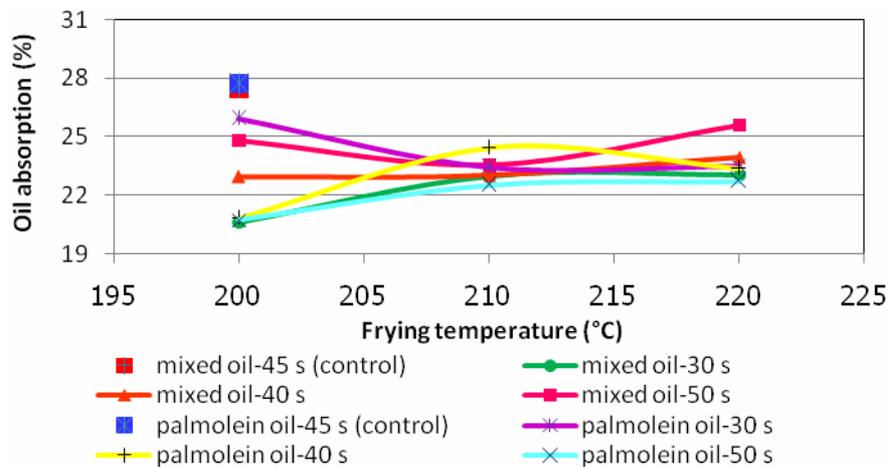


Figure 8. Effect of oil types, frying temperatures and frying times on oil absorption of crackers.

Examining the degradation of oils after frying rice crackers found that mixed oil was lower than palm olein in both CD and TBARS values (Figs.9 and 10). This is due to palm olein oil having a higher content of polyunsaturated fatty acids, especially oleic acids. It oxidizes more during frying than mixed oil that has more saturated fatty acid content (Marquez-Ruiz and Dobarganes, 1996). In commercial frying operations, palm olein oil is used more than mixed oil because it adds a special flavour of free fatty acids derived from lauric acid decomposition of coconut oil.

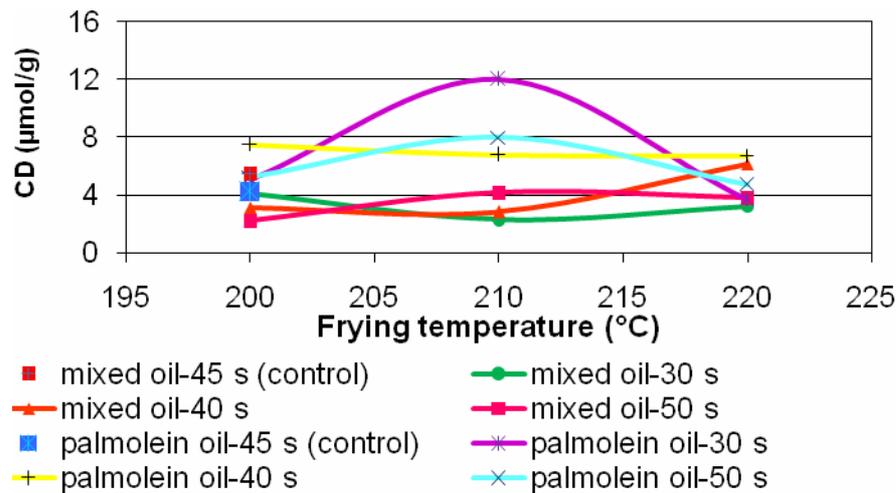


Figure 9. Effect of oil types, frying temperatures and frying times on the change of CD value in oil after frying crackers.

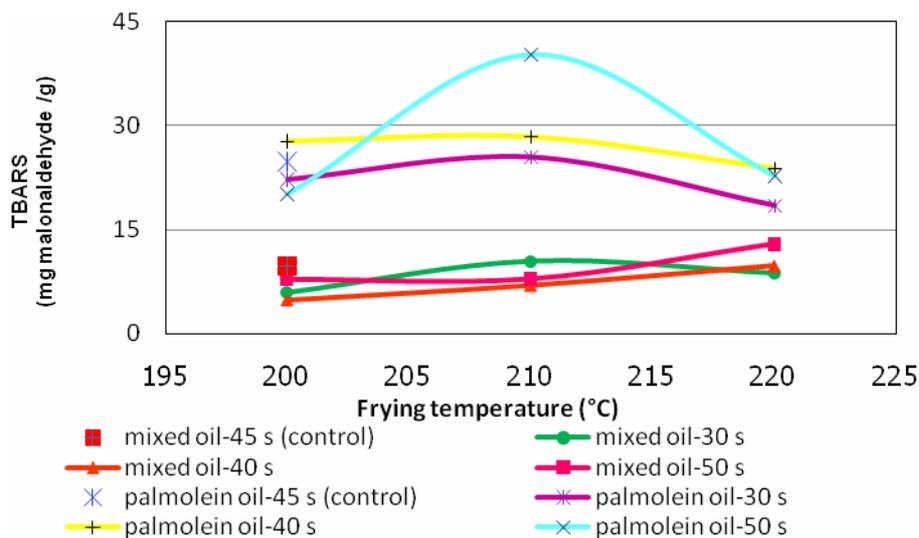


Figure 10. Effect of oil types, frying temperatures and frying times on the change of the TBARS value in oil after frying crackers.

Antioxidants Study

Rice crackers of 0.8 cm thickness and 4.0 cm diameter, dried at 65°C to 10% remaining moisture in a cabinet dryer and fried using palm olein oil at 210°C for 30 seconds were used in this study. The extracted oil from the stored fried rice crackers in Figure 11 shows that adding TBHQ to oil before frying has the most effect on antioxidants. Because the induction period of peroxide is longer and the amount of peroxide is lower than others throughout the storage time. This is due to the better heat stability of TBHQ (Sherwin and Thompson, 1967) and it has more hydroxyl groups in the molecule than BHA and BHT. TBARS values of all treatments were contrasted with PV due to it being a secondary oxidation product. Hydroperoxides, the primary oxidation product are very unstable and decomposed by fission, dehydration and formation of free radicals to form a secondary oxidation product (Moreira et al., 1999).

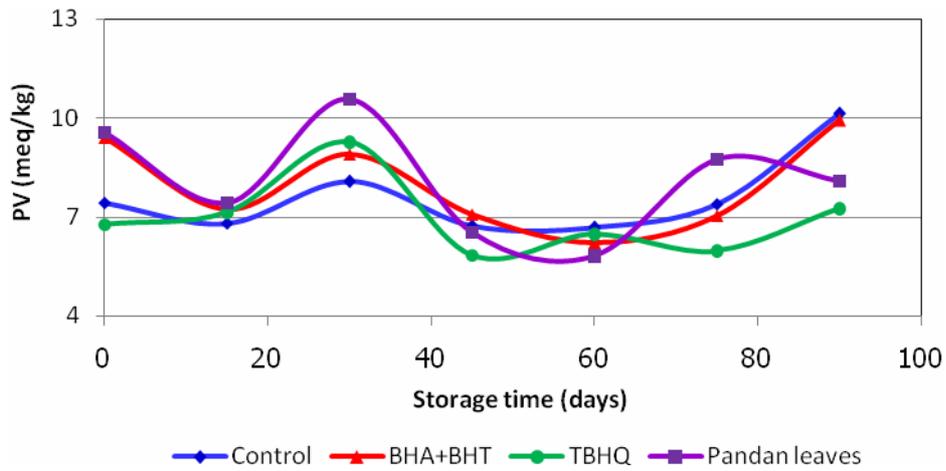


Figure 11. Effect of antioxidants on PV of oil extracted from 7 different storage times of crackers.

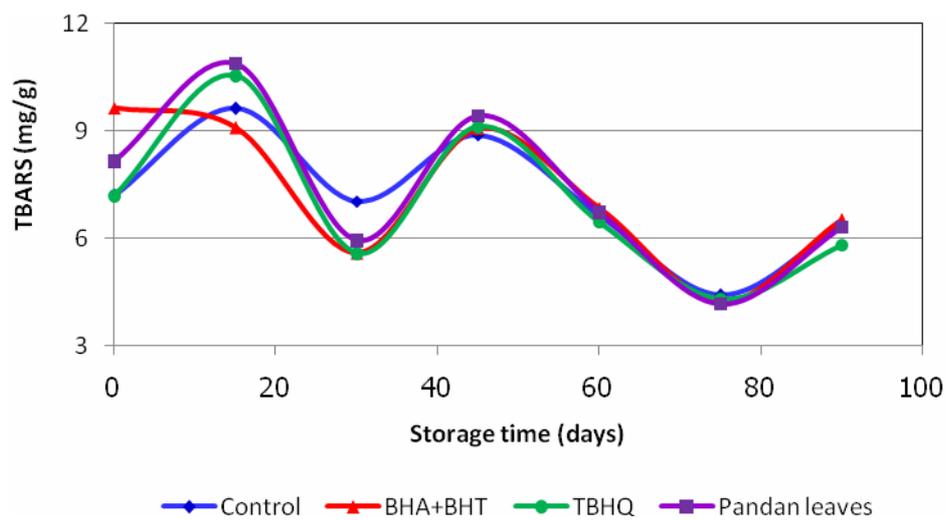


Figure 12. Effect of antioxidants on TBARS of oil extracted from 7 different storage times of crackers.

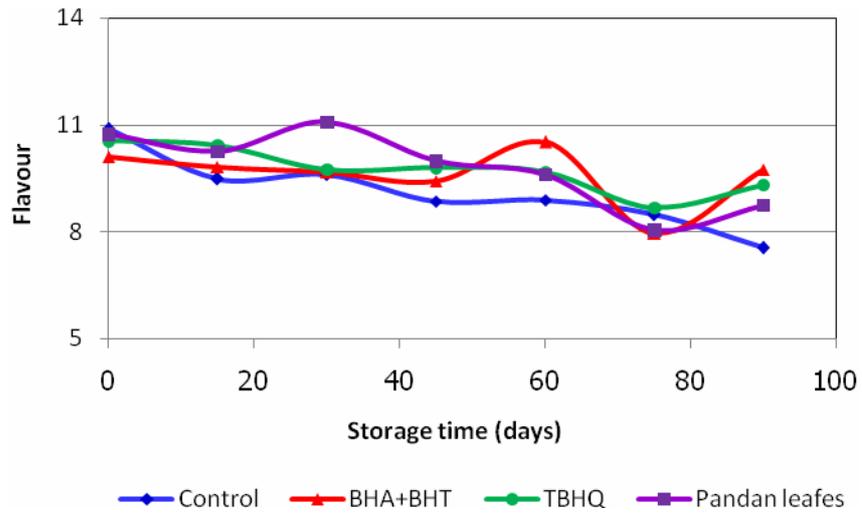


Figure 13. Effect of antioxidants on flavour scores of oil extracted from 7 different storage times of crackers.

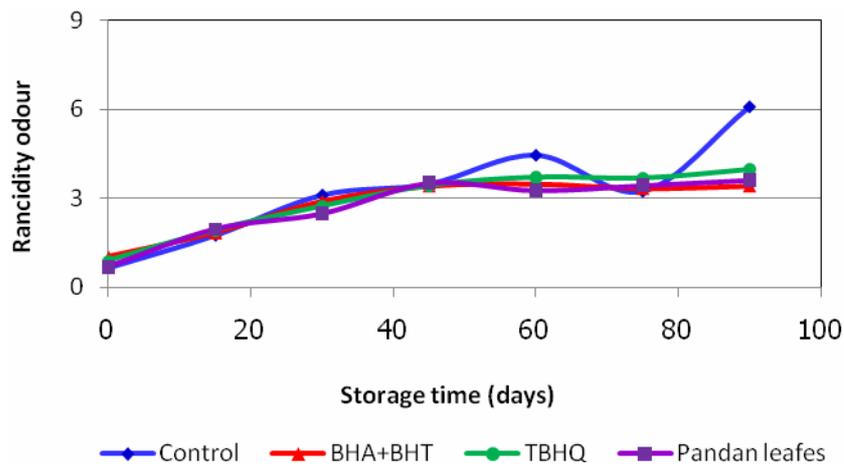


Figure 14. Effect of antioxidants on rancidity odour scores of oil extracted from 7 different storage times of crackers.

The average scores of the trained panelists, taken every 15 days, regarding flavour of the crackers in all treatments over a period of 90 storage days shows a decrease from the beginning to a minimum level at 75 days because of the oxidative products odour and the odour of antioxidant materials. After 75 days the scores increased due to the loss of antioxidant odour. The scores of nine or above are regarded as acceptable flavour. As a rancidity score of below three is acceptable, all treatments except the control treatments can be maintained for 60 days. TBHQ was found to have a better tendency than the others.

Conclusion

The optimal size for the molding process using small molds was 0.5 cm thickness because the amount of broken crackers after frying was low. The bigger mold with 0.8 cm thickness gave a more stable shape after removal than the others. Drying crackers at 65°C to achieve 10% remaining moisture gave good colour, high crispiness, low oil uptake and low degradation of frying oil. Frying crackers with palm olein oil at 210°C for 30 seconds gave the brightest colour, the least oil uptake and the least chemical change of frying oil with respect to CD and TBARS values. The addition of 200 ppm TBHQ to the frying oil tended to provide better results than others and storage time of good quality product in PP packaging was 60 days while the control was good within 30 days.

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