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PROOF RESEARCH PAPER

Palm Stearin as a Pork Back Fat Replacer for Semi-Dried Tilapia Sausage

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Abstract

This study characterised semi-dried tilapia sausages made using palm stearin as a pork back fat replacer. Palm stearin had significant effects on the colour of tilapia sausages. Palm stearin sausages had higher lightness (L^*), redness (a^*) and yellowness (b^*) values than the pork back fat sausages. Less expressible fluid was seen with the palm stearin sausages ($P<0.05$) and lower instrumental hardness, springiness, and chewiness than with pork back fat ($P<0.05$). However, no significant differences in all sensory attributes were found ($P\geq 0.05$). Moisture content and pH gradually decreased ($P<0.05$) whereas the water activity tended to remain stable in both sausages over 15 days of storage with vacuum packaging at room temperature. Increases in TBARS, total volatile base-nitrogen content, total plate count, and yeasts and moulds counts of both sausages were observed, indicating progressive lipid oxidation and microbial growth in both samples throughout the storage period. However, all quality parameters tested were within the Thai Community Product Standard required for safety. The decreases in L^*, a^* and b^* values for both sausages over time were related to an increase in a brown discolouration.

Keywords: Semi-dried sausage, tilapia, *Oreochromis niloticus*, pork back fat, *Elaeis guineensis*, palm stearin.

Introduction

A typical semi-dried sausage, known as "*Kun-cheang*" in Thai, is one of the most popular pork sausages in Thailand. However, this pork based product is not permitted for Muslim and Jewish consumers. To create a semi-dried sausage for the halal and kosher markets, sausages with other meat ingredients, particularly fish meat, have been formulated (Venugopal, 2009). Tilapia (*Oreochromis niloticus*) meat is of interest for sausage production because it is one of the economically important freshwater fish of Thailand, and represents about 76% of the total aquaculture production of tilapia worldwide (Rawdkuen *et al*., 2009). One study of tilapia gave an average composition of 80% water, 18% protein, 1% fat and 0.7% ash (Chaijan, 2011).

Fat is a crucial ingredient in sausages providing good sensory attributes, especially texture and flavour, to sausages. Pork back fat is the most widely used fat in sausages because of the superior taste and textural characteristic that comes from its higher saturated fatty acid content (Ospina *et al*., 2011). Choi *et al*. (2010) suggested that pork back fat plays a major role in forming stable emulsions, reducing cooking losses, improving water holding capacity and binding properties, and providing juiciness and hardness to sausage products. However, sausages with high saturated fat (approximately 20-30%) may have some health concerns (McNeill *et al*., 2012) although current thinking seems to suggest less concern (Feinman, 2010). Technologically, sausages need a certain amount of saturated fat to retain their shape at room temperature and for flavour development (Campagnol *et al*., 2012). Animal fats also are high in cholesterol which again may increase health risks although current thinking again suggests less concern (Feinman, 2010). If successful, the incorporation of vegetable fats instead of animal fats may improve the nutritional composition of meat products. Various vegetable oils have been incorporated into cooked and uncooked meat products. The effect of partial replacement by olive oil (Kayaardi and Gok, 2003), soybean oil (Muguerza *et al*., 2003), interesterified palm and cottonseed oils (Vural, 2003) on the colour, chemical and sensory properties of meat products have been studied. However, those products still incorporated some pork fat. The full replacement with vegetable fats remains challenging.

Vegetable fats like palm oil are stable and can be blended to obtain different levels of plasticity by using different proportions of stearin and olein

(Vanapalli *et al*., 2002). Palm stearin, a harder fraction of palm oil, is commercially produced from palm oil by fractionation. This fraction has a high melting point which ranges from 44.5-56.2°C (Edem, 2002). The predominant fatty acids in palm stearin are palmitic acid (61.2%), oleic acid (27.5%), linoleic acid (6.1%) and stearic acid (4%) (Che Man *et al*., 1999). This fatty acid composition is quite similar to that of pork back fat, which is typically palmitic acid (24%), oleic acid (36%) and linoleic acid (14%) but with a higher content of stearic acid (13%) leading to a higher degree of solidification (Wood *et al*., 2008; Ospina *et al*., 2011). Thus, palm stearin might possibly be used instead of pork back fat for a halal and kosher semi-dried tilapia fish sausage. The characteristics and storage stability of such products were evaluated in comparison with sausages made with pork back fat.

Materials and Methods

Live tilapia (*Oreochromis niloticus*) with an average weight of 300-400 g were purchased from the Thasala market, Nakhon Si Thammarat, Thailand in July, 2015. After percussive stunning, the fish were placed in ice with a fish/ice ratio of 1:2 (w/w) and transported to the Department of Food Technology, School of Agricultural Technology, Walailak University within 30 min. Upon arrival, the fish were immediately washed with cold water, headed, eviscerated and washed with cold (4°C) 0.4% sodium chloride solution. Thereafter, the fish were hand filleted to remove skins and bones. Fillets were then minced using a meat grinder (4 mm plate; Panasonic MK-G20MR, Tokyo, Japan). Samples were taken for proximate composition using AOAC (2000) methods 950.46, 928.08, 960.39 and 920.153 for moisture, protein, fat and ash contents, respectively. For the protein, a Kjeldahl conversion factor of 6.25 was used. The mince was kept on ice during sausage preparation.

The crude palm oil obtained from Thai Tallow and Oil Co. Ltd. (Nasan, Suratthani, Thailand) was melted and kept homogenized using an IKA Labortechnik homogenizer (Selangor, Malaysia) at 70°C to destroy all crystal memory. The melted oil was stirred with a magnetic stirrer at 25 rpm at 9°C until complete crystallization of the stearin fraction according to the modified method of Zaliha *et al*. (2004). During cooling, supercooling of the oil occurred resulting in nucleation and crystal growth. After stabilization, the mixed crystal and oil phases appeared as a thick semi-solid slurry. The slurry was then separated into olein and stearin using vacuum filtration with Whatman No. 41 filter paper (Maidenstone, England). The recovered palm stearin had a yellow colour. Pork back fat with 78.8% fat content was also obtained from the Thasala market. Pork back fat was minced using a meat grinder (4 mm plate; Panasonic MK-G20MR, Tokyo, Japan) prior to sausage production.

To produce semi-dried tilapia sausage, tilapia mince (62.8%) was kneaded using gloved hands with fat (15.7%), sugar (15.7%), sodium nitrite (1.73%) and sodium erythorbate (0.15%) (all by weight) for 10 min to obtain a thick homogenous batter. Thereafter, water (3.92%) was added and the kneading was continued for 2 min. Meat batters were stuffed into cellulose casings (2.5 cm in diameter, B.O.T Co., Ltd., Bangkok, Thailand) using a manual stuffer (Dick D-73779; Deizisau, Germany) and the sausages were hand tied with cotton strings at ~6 cm intervals. Each sausage link was ~50 g. Sausages were hung vertically in a tray drier (Owner Foods Machinery Co., Ltd., Bangkok, Thailand) and then dried at 60°C until the moisture content reached 25% as determined using an IR-35 Moisture Analyzer (Denver Instrument; Arvada, CO, U.S.A.). The sausages were then vacuum packed using a Multivac A300/16 vacuum-packaging machine (Sepp Haggmüller KG, Wolfertschwenden, Germany) and kept at room temperature (~25°C) overnight before analyses.

Colourimetric values of the samples were obtained, in triplicate, by using a portable Hunterlab Miniscan/EX instrument (10° standard observers, illuminant D65, Hunter Assoc. Laboratory; Reston, VA, U.S.A.). The sliced tilapia sausages sample were tightly packed into a 64 mm glass sample cup before colour analysis. The instrument was calibrated using the black glass and the standard white tile. The tristimulus L^* (lightness), a^* (redness/greenness), and b^* (yellowness/blueness) measurement mode was used as it best relates to the human eye's response to colour (Chaijan, 2011).

The following empirical procedure was carried out to measure emulsion stability based on a method proposed by Hughes *et al*. (1997). Approximately 25 g (exact weight recorded) of the sausage was placed in a weighed centrifuge tube (three replicates per formulation) and centrifuged for 3 min at 2,960×g at 25°C using a RC-5B plus centrifuge (Sorvall, Norwalk, CT, U.S.A.). The pelleted samples were removed and weighed. The percentage of total expressible fluid (TEF) was calculated as follows:

$$TEF\ (\%) = \frac{(Wt + Ws) - (Wt + Wp)}{Ws} \times 100$$

where Wt = weight of centrifuge tube; Ws = weight of sample, and Wp = weight of pellet.

For the texture analysis, three sausages were taken from each group randomly. Each piece cut with a knife (2.5 cm in diameter and 5 cm height) was tested using a two-stage compression using a texture analyser (TA-XT2i, StableMicro Systems Co. Ltd., Surrey, England), which had a 25 kg load cell and a 50 mm diameter probe (P/50 adaptor). The texture profile analysis (TPA) test was done with a 60% compression and the rate of the probe's movement was 1.0 mm/s. Hardness, springiness, cohesiveness and chewiness were recorded by the instrument's software.

Sensory analysis of semi-dried tilapia sausages was done in one session with two replicates. A 30-member untrained panel, consisting of undergraduate students, graduate students and employees of the School of Agricultural Technology, Walailak University (15 females and 15 males; age 18-32 years), evaluated the two types of sausages for appearance, colour, flavour, hardness, firmness and overall liking on a 9-point hedonic scale (9 = like extremely, 5 = neither like or dislike, 1 = dislike extremely). The samples (500 g) without casing were prepared by deep frying at 185±5°C with palm oil for 1 min. Pieces of sausages (2 cm length) were randomly distributed for evaluation. Samples were labelled with 3-digit codes and served using a counterbalanced order.

To examine the storage stability, separate 100 g samples were vacuum packed using the Multivac A300/16 and kept at room temperature (25°C) to imitate the commercial practice for such pork sausages in Thailand. The analyses were done on 0, 3, 6, 9, 12 and 15 days of storage.

Moisture content was determined using AOAC (2000) method 950.46. Water activity (a_w) was determined using an AquaLab CX-2 (Decagon Devices Inc., Pullman, WA, U.S.A.) with the temperature of samples at 25.0 ±1ºC.

Samples were homogenized using the IKA Labortechnik homogenizer with 10 volumes of deionized water (w/v) (GenPure^{TM}, Thermo Fisher Scientific, Waltham, MA, U.S.A.), and the pH was measured using a pH meter (Cyberscan 500, Singapore) at 25°C.

The thiobarbituric acid reactive substances (TBARS) assay was done as described by Buege and Aust (1978). Ground sausage (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 the homogenizer. The mixture was heated in a boiling water bath (95-100°C) for 10 min to develop a pink colour, cooled with running tap water and centrifuged at 3,600×*g* at 25°C for 20 min. The absorbance of the supernatant was measured at 532 nm, using a UV-1601 spectrophotometer (Shimadzu, Japan). A standard curve was prepared using 1,1,3,3-tetramethoxypropane (Sigma-Aldrich; St. Louis. MO, U.S.A.) at concentrations ranging from 0 to 10 ppm. TBARS were calculated and expressed as mg malondialdehyde (MDA) (Sigma-Aldrich; St. Louis. MO, U.S.A.) equivalent/kg sample from a standard curve prepared using MDA.

Total volatile base-nitrogen (TVB-N) was determined using the Conway micro-diffusion assay (Ng, 1987). A sample (2 g) was added to 8 ml of 4% TCA (w/v) and homogenized at 11,000 rpm for 2 min. The homogenate was centrifuged at 3,000×*g* for 15 min at room temperature. The supernatant referred to as the 'sample extract' (1 ml) was placed in the outer ring of the Conway apparatus. The inner ring solution (1% boric acid containing the Conway indicator (0.1% bromocresol green containing 0.2% methyl red (w/v)) was then pipetted into the inner ring. To initiate the reaction, K_2CO_3 (1 ml) was mixed with sample extract. The Conway unit was closed and incubated at 37°C for 60 min. The inner ring solution was then titrated with 0.02 N HCl until the green colour turned to pink. The TVB-N was expressed as mg N/100 g original sample.

The textural and colour properties of sausages with time were evaluated as describe earlier.

For microbial properties the samples were analysed for total plate count (TPC), and yeasts and moulds count according to standard procedures (APHA, 1992); for total plate count (37°C, 48 h) on nutrient agar and yeasts and moulds count on potato dextrose agar (PDA) (Sigma-Aldrich). Samples were aseptically removed, comminuted to fine particles in a Stomacher® 400 Circulator (Seward; West Sussex, UK) and then transferred to a test tube containing 9 ml of saline solutions and homogenized in a Vortex mixer (Scientific Industries, Inc.; Bohemia, NY, U.S.A.). Serial dilutions were made and samples at appropriate dilutions were inoculated into petri dishes containing the solid media. The colonies were counted after 24–48 h incubation and expressed in log cfu/g.

Data were subjected to analysis of variance (ANOVA). Comparison of means was carried out using Duncan's multiple-range test to identify significant differences ($P<0.05$) among treatments (Steel and Torrie, 1980). For pairwise comparisons, a *T*-test was used. Statistical analysis was done using the Statistical Package for Social Science (SPSS 10.0 for Windows, SPSS Inc., Chicago, IL, U.S.A.).

Results and Discussion

Colour values of sausages made with pork back fat and palm stearin are shown in Table 1. It was found that non-decolourised palm stearin sausages had higher lightness (L^*), redness (a^*) and yellowness (b^*) values than the pork back fat sausages ($P<0.05$). Generally, Chinese style sausages have a brown-red colour due to formation of nitrosomyoglobin. The addition of palm stearin markedly increased the redness/yellowness of the sausages due to its being a rich source of carotenoids, which should make the sausages healthier. Typically, crude palm oil contains 500-700 mg/kg of carotenoids and ~800 mg/kg of tocopherols (Chiu *et al*., 2009).

The total expressible fluids of sausages made with pork back fat and palm stearin are shown in Table 1. This parameter estimates the water and fat holding capacities of meat product and can be an indirect index for the emulsion stability of meat product. Higher lipid and water values suggest that the muscle proteins did not effectively bind or emulsify those fats and water. Semi-dried tilapia

Table 1. Colour, total expressible fluid, texture and sensory characteristics of semi-dried tilapia sausages formulated with palm stearin and pork back fat

Characteristics	Palm stearin based sausage	Pork back fat based sausage
Colour		
*L**	18.6 ±0.3[b]	16.8±0.1[a]
*a**	8.4±0.2[b]	4.7±0.2[a]
*b**	16.9±0.3[b]	8.7±0.1[a]
Total expressible fluid (%)	18.8 ± 0.7[a]	21.9 ± 1.4[b]
Texture		
Hardness (Kg)	8.1 ±0.1[a]	11.3±0.1[b]
Springiness (cm)	0.8 ± 0.2[a]	0.8 ± 0.3[a]
Cohesiveness	0.4 ± 0.1[a]	0.4 ± 0.1[a]
Chewiness (J)	0.3 ± 0.2[a]	0.3 ± 0.2[a]
Sensory attributes[#]		
Appearance	6.8 ±1.2[a]	7.1 ±1.1[a]
Colour	7.0 ±1.3[a]	7.2 ±1.1[a]
Flavour	6.4 ±1.5[a]	7.0 ±1.2[a]
Hardness	6.2 ±1.4[a]	6.4 ±1.3[a]
Firmness	6.7 ±1.5[b]	6.8 ±1.3[a]
Overall liking	7.6 ±1.3[a]	7.7 ±0.9[a]

Values are given as mean±standard deviation from triplicate determinations except for sensory test which are given as mean±standard deviation from scores provided by 30 panelists. Different letters in the same row indicate significant differences (P<0.05).

sausages are not considered to be an emulsion-type product because chopping to obtain a fine meat-fat mixture is not done. However, by manually kneading, a partial emulsion-like system was obtained. Sausages formulated with palm stearin showed lower total expressible fluids compared to the pork sausages (P<0.05) suggesting a better emulsion was formed although both had high expressible fluids (~19-22%) values.

Textural characteristics of both sausages are shown in Table 1. Typically, hardness reflects compression of a food between molars; springiness reflects the rate at which a deformed material returns towards its original condition after the deforming force is removed; cohesiveness reflects the strength of the internal bonds and chewiness reflects the energy required to chew the solid food prior to swallowing (Koç *et al*., 2013). Palm stearin sausages had a lower instrumental hardness than the pork sausages (P<0.05). However, no significant differences in springiness, cohesiveness and chewiness were found. (P≥0.05). Hugo and Roodt (2007) reported that fat gives meat products some of their textural attributes such as hardness, gumminess, juiciness and chewiness, as a result of its physical characteristics that depend on the fat's temperature and fatty acid composition. Generally, the firmness increases with more saturated fat (Ospina *et al*., 2011). Although the fatty acids of lard and palm stearin are similar, they differ with respect to C16:0, C18:0 and C18:2. Ospina *et al*. (2011) reported that the melting point and consistency of lard are related to its C18:0 content, which is 2.7 times that of palm stearin. In addition, palmitic acid (C16:0) may influence the consistency more at low temperatures when the slip point is used to measure the consistency. Thus, the differences in actual amounts of the various fatty acids may be responsible for the differences in textural characteristics, especially hardness, of sausages formulated with palm stearin and pork back fat.

The sensory results are shown in Table 1. No significant difference in sensory attributes were obtained (P≥0.05) possibly because of the limitations of using a relatively small untrained panel using a hedonic scale. The results suggested that total replacement with palm stearin had no detrimental effect on the sensory characteristics of semi-dried tilapia sausage and the average overall liking score of both sausages was greater than 7 on a 9-point hedonic scale, which bodes well for future commercial success.

The initial moisture content was set at about 25% (Figure 1a). During storage, moisture content was dramatically reduced in both sausages (P<0.05) (Figure 1a). The loss of 27.3 and 47.3% of the moisture for the palm and pork sausages after 15 days of storage presumably reflects evaporation through the casing. The lower loss with the palm stearin could be economically beneficial.

The change in a_w is shown in Figure 1b. The a_w of both sausages was stable over 15 days of storage period (Figure 1b). This result was similar to that reported by Menegas *et al*. (2013) for dried fermented chicken sausages produced with inulin and corn oil. Water activity is a critical factor determining the storage stability of meat products with respect to microbial and chemical deterioration. Interestingly, the moisture content of both sausages was equal in the beginning; yet, the a_w of both sausages was significantly different (P<0.05) with the palm sausages having a much higher a_w. This suggests that the water molecules in palm stearin sausages were less tightly bound than in the pork sausages. It is possible to have products with the same a_w but very

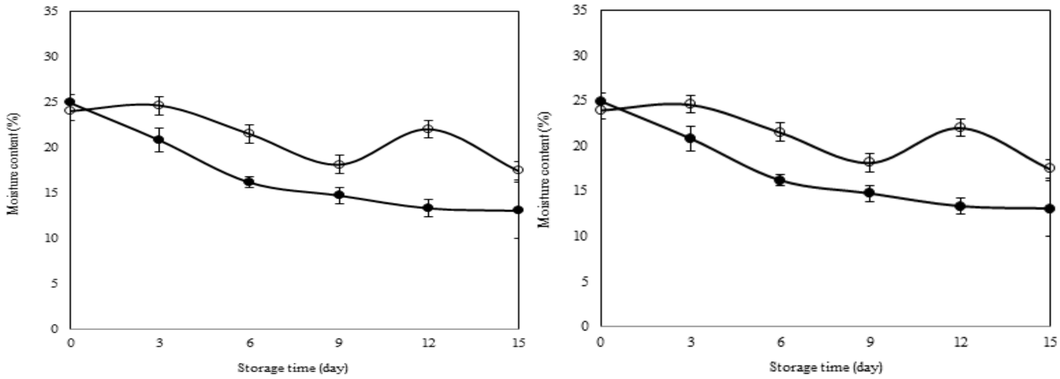

Figure 1. Changes in moisture content (a) and aw (b) of semi-dried tilapia sausages made with pork back fat (●) and palm stearin (○) during storage. *Bar indicates standard deviation from triplicate determinations.

different moisture contents because the measurements of moisture content and a_w are based on different principles (Mathlouthi, 2001). Yet, over time the palm sausages lost less moisture than the pork sausages, which was surprising and requires further elucidation (Figure 1a).

The fat type did not affect the pH of the sausage products (P≥0.05) (Figure 2a). The reduction of pH is probably due to the accumulation of lactic acid produced by lactic acid bacteria growing in the low oxygen environment of the vacuum-packed sausages. In this study the semi-dried Chinese-style tilapia sausage contained 15.7% of sucrose, which can be used by the lactic acid bacteria. The decrease in pH of both sausages during storage was correlated with the reduction of moisture content (Figure 1a) (R^2 = 0.818 and 0.687 for palm stearin sausages and pork back fat sausages, respectively). The lower pH increased the release of water, which is typical for meat products (Kuo *et al*., 1986).

The lipid oxidation changes are shown in Figure 2b. No significant differences in TBARS between treatments were observed (P≥0.05) but increases in TBARS for both sausages indicated progressive lipid oxidation. However, TBARS values were well below the threshold value (1.0 mg malondialdehyde equivalent/kg) for detection of warmed-over flavours (Boles and Parrish, 1990), thus suggesting that vacuum-packaged semi-dried tilapia sausages could be stored at room temperature for up to 15 days without any serious rancidity problems. Kuo *et al*. (1986) studied the effect of packaging on the quality of Chinese sausages and showed that the use of vacuum packaging can be an appropriate means to reduce lipid oxidation. Although palm stearin has a higher content of unsaturated fatty acids, particularly oleic acid, than pork back fat, the degree of lipid oxidation of both sausages was relatively similar. It was possible that the natural occurring antioxidants such as carotenoids and tocopherols in palm stearin retarded the autooxidation of those fatty acids.

TVB-N is mainly a measure of ammonia, and primary, secondary and tertiary amines resulting from the degradation of proteins and non-protein nitrogenous compounds mainly by microbial activity. A level of 35-40 mg TVB-N/100 g of fish muscle is sometimes regarded as spoiled (Lakshmanan, 2000) although other higher values have been suggested (Ababouch *et al*., 1996). Changes in TVB-N values for both sausages are shown in Figure 2c. The values increased gradually in both samples during storage (P<0.05). These changes were significantly greater in palm stearin sausages than the pork back fat sausages. This might be attributed to higher moisture content and a_w of palm stearin sausages (Figure 1a and 1b) which can allow for the proliferation of microorganisms.

The textural characteristics during storage are shown in Figure 3a-d. When pork back fat was replaced by palm stearin, hardness (Figure 3a), springiness (Figure 3b) and chewiness (Figure 3c) decreased throughout the storage period (P<0.05). However, fluctuation of cohesiveness among the samples during storage (Figure 3d) made this measurement more problematic. No significant differences in cohesiveness between the sausages was observed within the first 6 days of storage (P≥0.05) whereas a higher value was obtained for the pork back fat sausages at the end of storage (P<0.05). The results clearly showed that the fat type influenced the textural characteristics. It was also noted that in both sausages the springiness (Figure 3b), chewiness (Figure 3c) and cohesiveness (Figure 3d) tended to remain constant during the 15-days of storage whereas hardness slightly decreased after day 6 of storage (Figure 3a).

Changes in the colour during storage are shown in Figure 4a-c. Generally, the rate of meat product discolouration is related to the redox instability of the different forms of myoglobin in meat on the *L**, *a**, and *b** values (Faustman *et al*., 2010). The initial *L** values decreased after 15 days of storage (P<0.05) (Figure 4a). The reduction of the *L** value resulted in a brown discolouration which could be due to Maillard browning reaction, oxidation of myoglobin and/or degradation of carotenoids. It was previously reported that myoglobin oxidation decreases lightness and shows a positive relationship with lipid oxidation

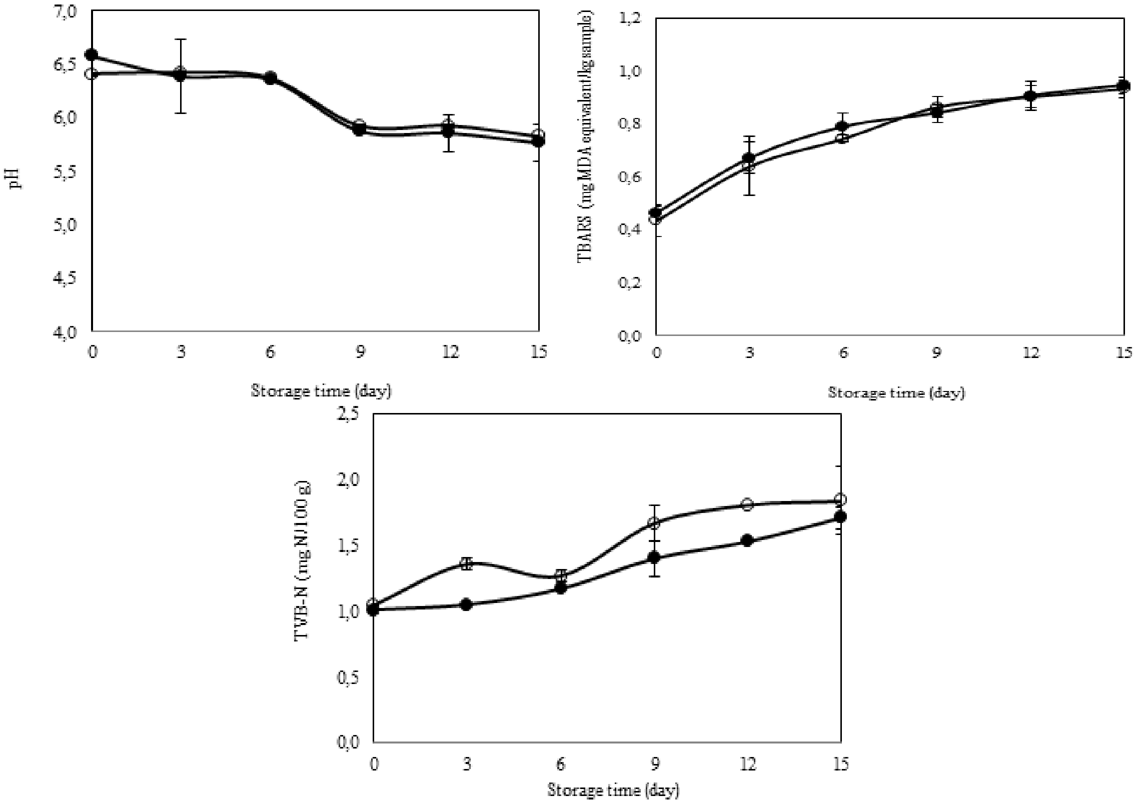

Figure 2. Changes in pH (a), TBARS (b) and TVB-N content (c) of semi-dried tilapia sausages made with pork back fat (●) and palm stearin (○) during storage. *Bar indicates standard deviation from triplicate determinations.

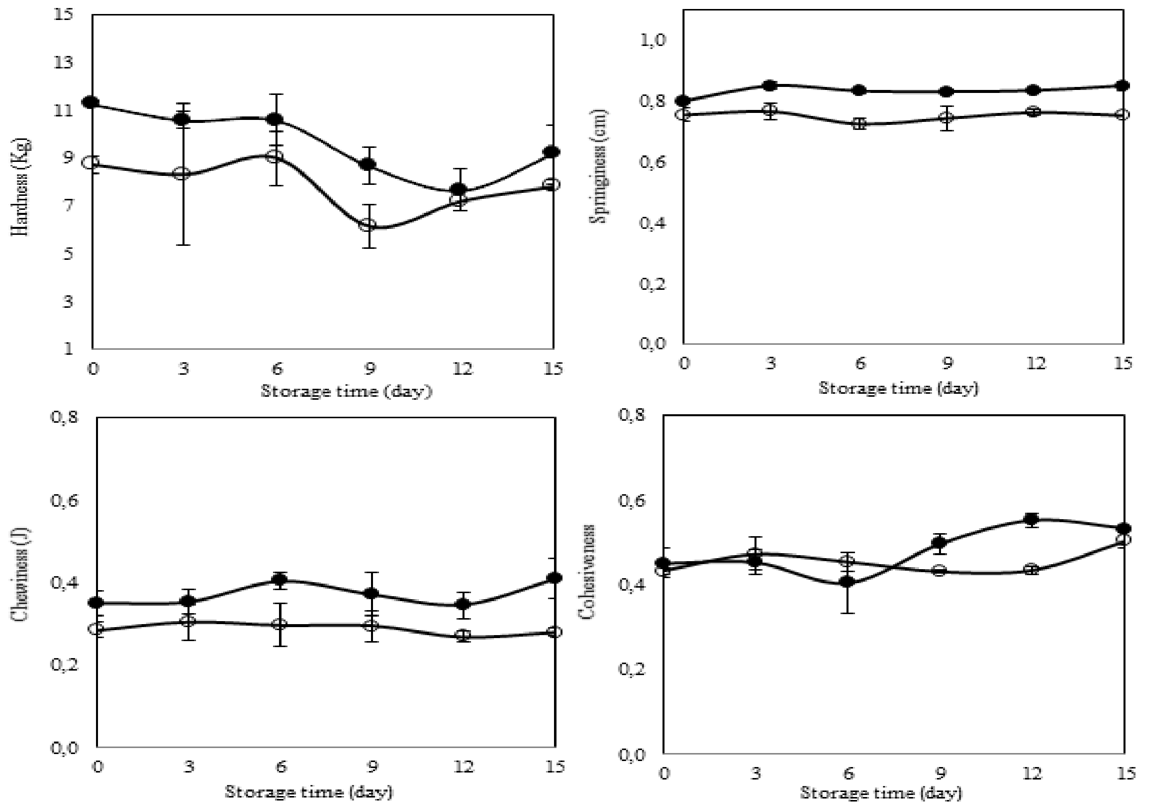

Figure 3. Changes in hardness (a), springiness (b), chewiness (c) and cohesiveness (d) of semi-dried tilapia sausages made with pork back fat (●) and palm stearin (○) during storage. *Bar indicates standard deviation from triplicate determinations.

(Faustman *et al*., 2010). The rate of *L** reduction in palm stearin sausages was greater than in pork back fat sausages (40 vs 13%) which was possibly due to the degradation and/or bleaching of carotenoids. After 15 days of storage, the *a** value of palm stearin sausages decreased significantly (P<0.05) but no significant difference in *a** value was observed in the pork fat back sausages (P≥0.05) (Figure 4b). The different responses were probably due to the oxidation of carotenoids and the accumulation of brown metmyoglobin mediated by oxidised carotenoids. The *b** value of palm stearin sausages tended to remain constant during 12 days of storage and sharply dropped at the end of storage (P<0.05) whereas it gradually decreased in the pork back fat sausages throughout the storage period (P<0.05) (Figure 4c).

Microbiological analyses of the sausages are shown in Figure 5a-b. Total plate counts (Figure 5a), and yeasts and moulds counts (Figure 5b) increased over the storage period in both sausages. Total plate counts were similar for both products (Figure 5a) but a more rapid increase of yeasts and moulds was found in the palm stearin sausages (Figure 5b) probably due to its higher moisture content (Figure 1a) and a_w (Figure 1b). The Thai Community Product Standard for semi-dried Chinese-style sausage (*Kun-cheang*) requires that the total microorganism content be less than 1×10^5 colonies/g sample and that the yeasts and moulds counts be less than 100 colonies/g samples (Thai Community Product Standard, 2003).

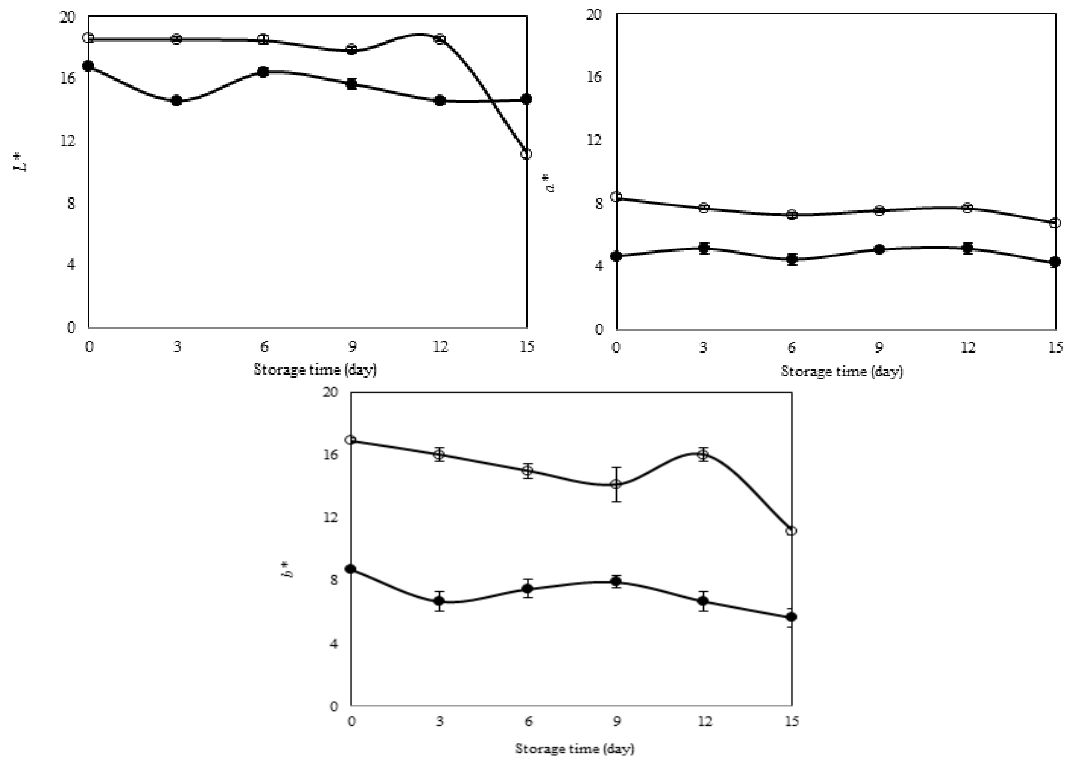

Figure 4. Changes in lightness (*L**) (a), redness (*a**) (b) and yellowness (*b**) (c) of semi-dried tilapia sausages made with pork back fat (●) and palm stearin (○) during storage. *Bar indicates standard deviation from triplicate determinations.

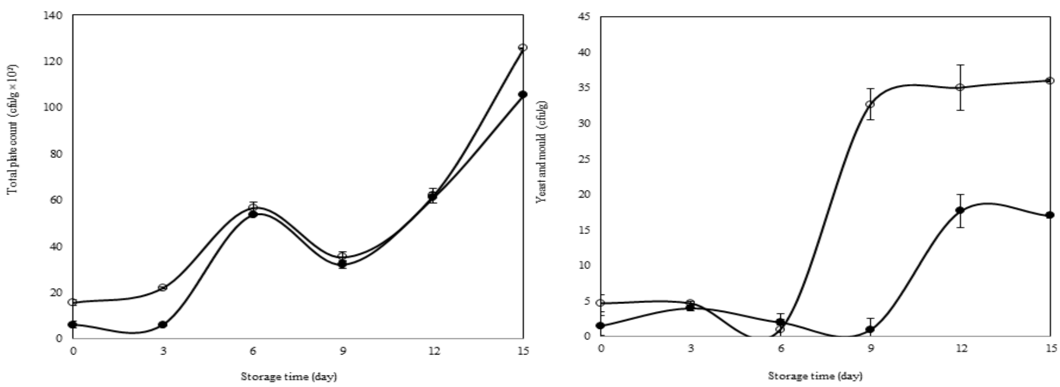

Figure 5. Changes in total plate counts (a) and yeast and mold counts (b) of semi-dried tilapia sausages made with pork back fat (●) and palm stearin (○) during storage. *Bar indicates standard deviation from triplicate determinations.

According to that standard, both sausages were still in compliance after 15 days.

Conclusion

This study showed that palm staerin might be able to replace pork back fat in semi-dried tilapia sausages. Only the hardness was greater in pork back fat sausages compared to palm stearin sausages. Both types of sausages had highly acceptable sensory characteristics. Both sausages during vacuum packaged storage at room temperature for 15 days met both microbial and lipid oxidation standards suggesting that both were safe and acceptable for consumption after 15 days.

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