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Frying Process Improvement and Shelf Life Studies of Fried Boneless Salted Sepat-Siam

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ABSTRACT

Fried, boneless, salted, Sepat-Siam (*Trichogaster pectoralis* Regan) has a short shelf life due to its frying process and type of packaging. The objectives of this research were to: 1) evaluate pre-frying methods, 2) compare atmospheric frying conditions with vacuum frying conditions, and 3) study shelf life and quality of fried, boneless, salted, Sepat-Siam in the easy-open cans at different conditions. An improved frying process involved three steps: 1) The pre-process to reduce moisture content of salted Sepat-Siam from 78.35% to 62.31% by frying at 170°C for 10 minutes which is significantly better than oven drying at 200°C for 15 minutes, 2) Removal of bones, fins and tail of salted Sepat-Siam, and 3) Frying under atmospheric condition (760 mm Hg) at 170°C for 15 minutes resulted in a product, fried, boneless, salted, Sepat-Siam, which had 33.05% oil content in comparison with 16.59% oil content of the fish fried under vacuum frying condition (150 mm Hg(abs)) at 140°C for 15 minutes. The shelf life of fried, boneless, salted Sepat-Siam under atmospheric and vacuum frying conditions stored at room temperature (30±2°C), packed in an easy-open can with an oxygen absorber were 18 weeks and more than 20 weeks, but without an oxygen absorber were 12 and 18 weeks, respectively. The nutritional values of 100 grams of fried, boneless, salted Sepat-Siam were 517.81 Kcal energy, 55.37 g protein, 30.05 g fat, 6.47 g carbohydrate, 0.58 g fiber, 312.01 mg calcium, 29.81 mg phosphorus, and 4.31 g sodium chloride.

Key words: Sepat-Siam, fried food, frying process, process improvement, shelf life studies

INTRODUCTION

Sepat-Siam (*Trichogaster pectoralis* Regan), called leaf fish because of its shape, is a significant economic freshwater fish of Thailand. It is the raw material used to make a traditional salted fishery product, named as dried, salted Sepat-Siam. Sepat-Siam farming is mostly located in central Thailand, especially in the areas of Suphanburi and Samutprakarn. After harvest, the fish are salted and dried for a day or a few day to make slightly salted Sepat-Siam and very strong salted Sepat-Siam. The price of both products is high but they are popularly consumed by the Thai people, and also there is a big demand to produce dried, salted Sepat-Siam for the export market (Pruerk Um Pai, 1988). The price of small-size, dried, salted Sepat-Siam is relatively low, so it is not popular to use small-size Sepat-Siam in the production of dried and slightly salted Sepat-Siam.

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Instead it is used as raw material in the production of value added, fried, salted Sepat-Siam. At present, processors who produce and market fried, salted Sepat-Siam pack this product in polyethylene bags or in unsealed stronger containers. To produce the product, the dried, salted Sepat-Siam are cleaned, and bones, fins and tails are removed. The fillets (half of each fish) are fried in vegetable oil until crispy. The products contain a large amount of oil from frying. The frying oil in the product reacts with oxygen, which leads to rapid oil deterioration and off-flavor during storage without controlled packaging. Vacuum frying, a process which reduces air content during frying, increases water evaporation at temperatures lower than 100°C. The objectives of this research were to: 1) evaluate pre-frying methods, 2) compare atmospheric frying conditions with vacuum frying conditions, and 3) to study shelf life and quality of fried, boneless, salted, Sepat-Siam in easy-open cans at different conditions.

MATERIALS AND METHODS

1. Raw materials: One hundred kilograms of salted Sepat-Siam used throughout this study was purchased from the Good Agricultural Practice Sepat-Siam farming ponds in Umphor Bang-Bor, Samutprakarn Province. They were in the grade of 16-18 fish per kilogram and were stored at -20°C until used. The salted Sepat-Siam were randomly sampled to determine moisture, protein, fat, salt, pH, a_W, total plate count, yeast and mold, and *Staphylococcus aureus*.

2. Pre-process comparison between oven and frying methods : Pre-process methods were used to reduce initial moisture content of dried, salted Sepat-Siam before deep-frying to facilitate bone, fin, and tail removal. Two pre-process methods were examined: 1) oven heated at 200°C for 15 minutes, and 2) deep-frying at 170°C for 10 minutes. Moisture content of fish samples from both methods were determined.

3. Determination of the optimum atmospheric and vacuum deep-frying conditions of salted Sepat-Siam.

3.1 The optimum atmospheric deep fat frying conditions of salted Sepat-Siam. Chosen pre-processed boneless, salted Sepat-Siam (300 g) were fried under atmospheric conditions in 3 kg Olein Palm Oil. A 3×3×2 factorial experiment in completely randomized block design with 3 replications was used. There were three frying temperatures (160, 170 and 180°C), three frying times (15, 20 and 25 minutes), and two pre-process methods (oven and frying). After deep-frying, the samples were drained and cooled for 10 minutes before packaging in polyethylene bags. Physical, chemical, and microbiological qualities were determined..

3.2 The optimum vacuum deep fat frying conditions of salted Sepat-Siam. Chosen pre-processed boneless, salted Sepat-Siam (300 g) were fried under vacuum conditions in 80 kg Olein Palm Oil in frying machine of Marchcool Industry Co., Ltd.

Frying time was 30 minutes and the vacuum pressure was 150 mm Hg (abs). Frying temperatures were 100, 110, 120, 130, 140 and 150°C. The appearance of samples was described and recorded as data. A 3×3 factorial experiment in completely randomized design with 3 replications was used. There were three frying temperatures (130, 140 and 150°C), and three vacuum pressures (150, 360 and 600 mm Hg (abs)). Frying time was 30 minutes. After deep-frying, samples were drained and cooled for 10 minutes before packaging in polyethylene bags. Physical, chemical, and microbiological quality were determined.

4. Determination of quality of deep- fried boneless, salted Sepat-Siam.

Proximate analysis of moisture, fat, protein,

crude fiber and carbohydrate of fried boneless salted Sepat-Siam samples were determined following AOAC (2000). Texture analysis for hardness was done with a Lloyd Analyzer model TA 500. Calcium, phosphorus, sodium chloride and fatty acid composition were determined (FAO, 1981). Carbohydrate, total energy, and nutritional data were determined.

Sensory analysis of fried, salted Sepat-Siam was determined using Quantitative Descriptive Analysis (Stone and Sidel, 2004). The terms such as appearance, color, crispness, hardness, stickiness were used to define the quality attributes of the products. Eleven trained panelist were selected and trained following ASTM methods (2000). The quality attributes were defined by the trained panelists, and intensity was rated on a 15 cm. line scale.

6. Shelf life studies of fried, boneless, salted Sepat-Siam.

Fried, boneless, salted Sepat-Siam from the optimum deep-frying process both under the atmospheric and vacuum conditions were compared over storage time. The products of all treatments were packed immediately after cooling in metal cans with inner aluminum sealed easy-open lid, and outer plastic lid. The can dimensions were 7 cm. in height and 8 cm. inner diameter. A 2^3 factorial experiment in completely randomized design with 3 replication was used for 2 frying conditions (atmospheric and vacuum), 2 packing conditions (with and without oxygen absorber (RP-200 type of Janejaras Chem Supply)), and 2 storage temperatures (at 4°C and room temperatures (30±2°C)).

Samples were randomly taken every 2 weeks for 5 months. Samples were analyzed for moisture content, fat content, salt, pH, acid value, peroxide value, thiobarbituric acid number (Kirk and Sawyer, 1991), a_W, color (CIE L* a* b*) by spectrophotometer, texture on hardness, total plate count (Miwa and Low, 1992), yeast and mold (Pitt and Hucking, 1985)

RESULT AND DISCUSSION

Raw materials : Salted Sepat-Siam samples in this study contained 78.35 % moisture content, 18.9 % protein content, 4.77 % fat content, 4.48 % salt content, pH =6.57, a_W =0.96, total plate count = $2.32 \times 10^5 - 2.78 \times 10^5$ colonies per gram, yeast and mold = 1.7×10^2 colony per gram, and *Staphylococcus aureus* was not found. The microbiological determination resulted in a higher total plate count than minimum standard (TISI, 1993). This was from the fact that salted Sepat-Siam selected for processing contained high moisture content and high a_W , with low salt content. This condition was suitable for the growth of microorganisms. Therefore it was necessary to store the salted Sepat-Siam in a –20°C freezer throughout the studies.

Preprocess method : In the preprocess step to reduce moisture content and to precook salted Sepat-Siam, the result was that deep-frying at 170°C for 10 minutes (62.31% moisture content) reduced moisture content significantly better ($p \leq 0.05$) than oven drying at 200°C for 15 minutes (70.23 % moisture content). Therefore the preprocess of deep-frying at 170°C for 10 minutes was chosen as the preprocessing method in the following studies.

The optimum atmospheric deep-frying process of salted Sepat-Siam was 170°C for 15 minutes. The product from this preprocess and deep-frying process after boning had acceptable characteristic with crispy, yellow-brown color. The optimum vacuum deep-frying process of salted Sepat-Siam aimed for proper temperature, time, and pressure. At a temperature of 100–120°C and 30 minute frying time, the products were not cooked or not uniformly cooked, and were not soft and sticky and not crispy. Apparently the temperature was too low for vacuum deep-frying fish. When the temperature was increased to

130–150°C, the product was thoroughly cooked to be crispy, and uniform in color. Therefore, the deep-frying temperature of 130–150 °C was chosen for study 3.2 which was the experiment on varying pressure. The optimum conditions for vacuum deep-frying was 140°C for 15 minutes, and pressure of 150 mm Hg (abs). The characteristics of the product were good appearance, crispy, with yellow-brown color, and low moisture content.

The analysis of moisture content of the finished products from atmospheric deep-frying indicated that moisture contents of fried salted Sepat-Siam samples declined when frying times and frying temperatures were increased. These results were confirmed with data reported in Krokida *et al*. (2000). The moisture content of fried, salted Sepat-Siam samples from vacuum deep-frying with decreasing pressure were decreased at the $p \leq 0.05$ significant level (Figure 1a). The fried, salted Sepat-Siam from atmospheric deep-frying had increasing fat content as frying times and frying temperatures were increased. The fried, salted Sepat-Siam from vacuum deep-frying with decreasing pressure also had significantly increased fat contents (Figure1b). The fried, salted Sepat-Siam from atmospheric deep-frying had increased texture as frying times and frying temperatures increased. This was a result of decreasing moisture content. The hardness value of the fried, salted Sepat-Siam from vacuum deep-frying with decreasing pressure also significantly increased as pressure was decreased (Figure 1c). The texture of fried, salted Sepat-Siam was more crispy when frying pressure was decreased. Deep-frying of foods under decreasing pressure in the closed system can reduce the boiling point of frying oil and water in foods. The oxygen content in the vacuum frying system was also less than atmospheric frying (Hidaka *et al.*, 1991). These conditions can help preserve color, odor, and flavor of the product, and help preserve the quality of frying oil (Tawong, 2000). It also decreases the quality change of vegetable oil used and the amount of retaining oil (Saguy and Pinthus, 1995). Reduction of pressure in the frying system at a pressure 150, 360, and 600 mm Hg(abs), at vapor pressure of pure water 32, 48, and 80 Kpa., water can change to steam at a temperature of 60, 80, and 93°C, respectively (Montri, 1993).

The analyses of quality, chemical, physical and nutritional values were done on fried salted Sepat-Siam preprocessed at 170°C for 10 minutes, bone, fin and tail removed, fried again in either atmospheric conditions at 170°C for 15 minutes or vacuum conditions at 140°C for 15 minutes with pressure 150 mm Hg(abs). Data are shown in Tables 2 and 3, respectively. Both samples contained high nutritional values and relatively high protein and fat content. Fried, salted Sepat-Siam from vacuum frying had less fat content. Fat in fried, salted Sepat-Siam was composed of both saturated and unsaturated fatty acids in the amounts, 13.49 and 16.56 gram in 100 gram. Fatty acid composition analysis in 100 gram fried, salted Sepat-Siam was shown in Table 4. It was found that unsaturated Oleic acid was highest as 13.05 grams, while saturated Palmitic acid was 11.78 grams. These two fatty acids are frequently found in palm oil used in frying the salted Sepat-Siam. Fried, salted Sepat-Siam from the study was rich in calcium (312.01 mgs/100g), phosphorus (29.81 mgs/100g), and sodium chloride (4.63 gms/100g).

Shelf life of atmospheric and vacuum fried salted Sepat-Siam packed in an easy-opened can with or without oxygen absorber, kept at room temperature (30±2°C) and 4°C were studied. Samples were drawn out every 2 weeks for 5 months and analyzed for chemical, physical and microbiological qualities. The results showed that atmospheric and vacuum fried salted Sepat Siam packed in an easy-open can with oxygen absorber, kept at room temperature (30±2°C) had shelf life of 18 and more than 20 weeks. But atmospheric and vacuum fried, salted Sepat- Siam packed in an easy-open can without oxygen absorber, kept at

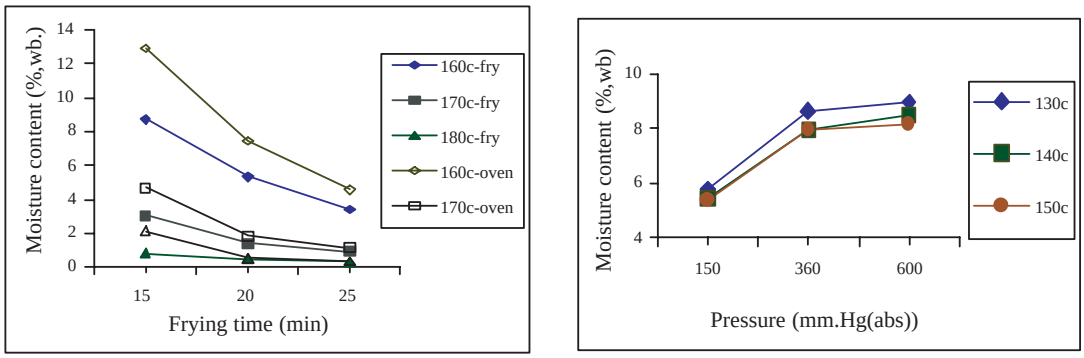

Figure 1a Percent Moisture content after frying.

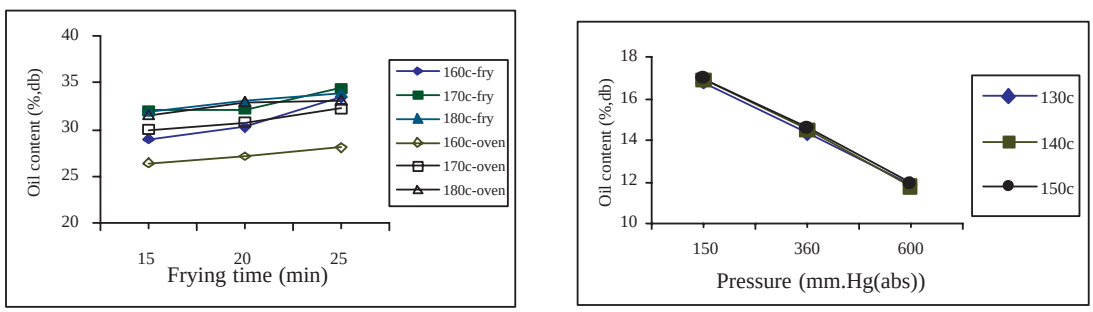

Figure 1b Percent oil content after frying.

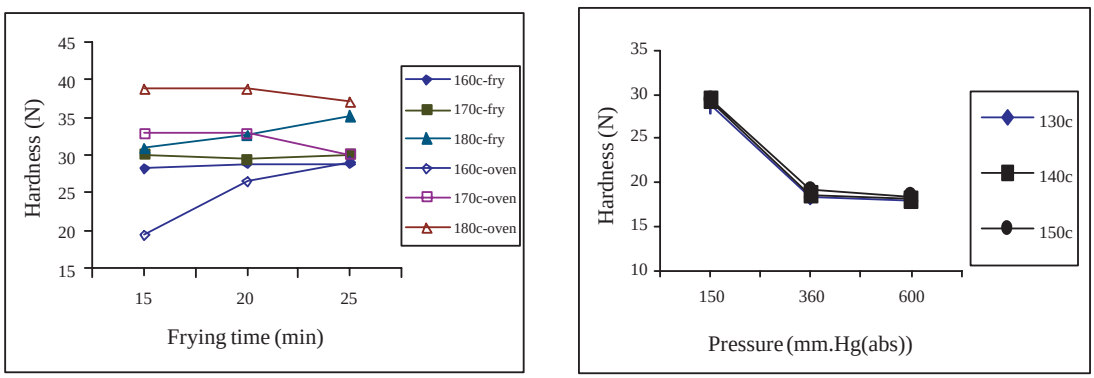

Figure 1c Hardness after frying (N).

Figure 1 Changes of moisture, oil contents and hardness of fried, boneless, Sepat-Siam at different time and temperature of frying in the atmospheric (left) and vacuum (right) conditions.

room temperature (30±2°C) had shelf life of 12 and 18 weeks. If the atmospheric and vacuum fried, salted Sepat- Siam packed in an easy-opened can with or without oxygen absorber, were kept at 4°C, the shelf life would be more than 20 weeks.

CONCLUSION

The optimum atmospheric deep-frying process of salted Sepat-Siam was at a temperature of 170°C for 15 minutes. The optimum vacuum deep-frying process of salted Sepat-Siam was at a

Table 1 Qualities of raw Sepat-Siam.

Qualities	
Moisture content	78.35%
Fat content	4.77%
Protein	18.9%
NaCl	4.48%
pH value	6.57
Water activity (a_W)	0.96
Total plate count (CFU/g)	$2.32–2.78 \times 10^6$
Yeast-Mold (CFU/g)	1.7×10^2
Staphylococcus aureus (CFU/g)	none

Table 2 Chemical and physical qualities of fried, boneless, salted, Sepat-Siam.

Qualities	Condition	
	Normal	Vacuum
Chemical		
Moisture (%)	3.45b	4.28a
Fat (%)	30.05a	16.59b
Sodium chloride (%)	4.63a	5.04a
pH	6.47a	6.45a
AV (mg KOH / g of oil)	0.34a	0.28b
PV (meq Peroxide/Kg)	6.75a	5.09b
TBA (mg malonaldehyde/Kg)	0.88a	0.32b
Physical		
aW	0.32a	0.37a
Hardness (N)	27.54b	29.02a
Color L*	49.36b	58.95a
a*	4.04a	4.67a
b*	18.64b	20.21a

Note : a, b = Data with different letters are significantly different ($p \leq 0.05$)

temperature of 140°C for 15 minutes and pressure of 150 mm Hg(abs). The atmospheric fried salted Sepat-Siam contained higher fat content, higher peroxide value (PV), and higher thiobarbituric value (TBA)

Fried, boneless, salted Sepat-Siam is a high nutritional food. It contains high levels of palmitic and oleic acids, minerals, especially calcium and phosphorus, and sodium chloride.

The packaging of fried, boneless, salted Sepat-Siam in an easy- open can with oxygen absorber can keep product quality and prolong

Table 3 Nutritional value of fried, boneless, salted, Sepat-Siam.

	Per 100 grams
Energy (K cal)	516.49
Protein (g)	55.37
Fat (g)	30.05
Sat. fatty acid (g)	13.49
Unsat.fatty acid (g)	16.56
Total carbohydrate (g)	6.14
Ash (g)	4.41
Fiber (g)	0.58
Calcium (mg)	312.01
Phosphorus (mg)	29.81
Sodium chloride (g)	4.63
Moisture (%)	3.45

Table 4 Fatty acid composition of fried boneless salted Sepat-Siam.

Fatty Acid Composition*	Content (g/100 g)
Lauric acid	0.07
Myristic acid	0.27
Palmitic acid	11.78
Palmitoleic acid (C16:1 n-7)	0.11
Magaric acid	0.03
Stearic acid	1.21
Oleic acid (C18:1 n-9)	13.05
Linoleic acid	3.2
a-Linolenic acid (C18:3 n-3)	0.06
Arachidic acid	0.09
Gondoic acid	0.05
Eicosatetraenoic acid	0.01
Behenic acid	0.02
Cervonic acid (DHA)	0.02
Lignoceric acid (C24:0)	0.02
Unidentified peak	0.06

Note : * in the form of fatty acid methyl ester

shelf life of the product better than packaging without an oxygen absorber. Vacuum fried, salted, Sepat-Siam has longer shelf life than the atmospheric, fried, salted, Sepat-Siam.

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