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Effects of Palm Fat Blends Inclusion on the Quality of Chicken Frankfurters

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ABSTRAK

Tiga jenis lelemak sawit (PF) diproses daripada pelbagai adunan minyak sawit (PO) dan stearin sawit (POs) pada nisbah PO:POs bersamaan dengan 60:40, 70:30 dan 80:20 (berat/berat). Takat gelinciran (SMP), nilai iodin (IV) serta kandungan lemak pepejal (SFC) PF diukur. Lapan formulasi sosej ayam kemudian diproses menggunakan lelemak sawit PF60:40, PF70:30, PF80:20 serta olein sawit (POo) pada paras lemak 20% dan 25%. Ukuran-ukuran suhu pencincangan, kestabilan emulsi (ES) serta keupayaan memegang air (WHC) dilakukan ke atas adunan sosej ayam. Pada tahap lemak 25%, adunan daging yang dicampur dengan PF60:40 dan POo masing-masing mencatatkan suhu tertinggi dan terendah di akhir proses pencincangan. Adunan daging PF60:40 dan PF80:20 menghasilkan kehilangan cecair yang lebih rendah pada tahap 20% berbanding 25% (P<0.05). Formulasi yang dicampur dengan PF menunjukkan keupayaan memegang air yang lebih tinggi daripada formulasi POo (P<0.05).

ABSTRACT

Three types of palm fats (PF) to be incorporated into meat batters were prepared from palm oil (PO) and palm stearin (POs) with the ratio of PO:POs at 60:40, 70:30 and 80:20 (wt/wt). The slip melting point (SMP), iodine value (IV) and solid fat content (SFC) of PF were measured. Eight formulations of frankfurters were then produced using PF60:40, PF70:30, PF80:20 and palm olein (POo) at 20% and 25% of fat levels. Chopping temperature, emulsion stability (ES) and water holding capacity (WHC) of meat batters containing PF and POo were measured. At 25% fat level, meat batters mixed with PF60: 40 recorded the highest final chopping temperatures at the end of comminution, while POo recorded the lowest value. Fluid loss of meat batters prepared with PF60:40 and PF80:20 were significantly lower at 20% fat level compared to that of 25% (P<0.05). Higher WHC was exhibited by meat batters containing various PF compared to the one with POo (P<0.05).

INTRODUCTION

Studies of incorporation of plastic fats into meat emulsion have been reported by Lee *et al.* (1981a, 1981b, 1981c), Septon *et al.* (1993) and Babji *et al.* (1998). Effects of fat's physical properties in emulsion stabilization were investigated by Lee *et al.* (1981c). Thermal stability of emulsion was inversely related to fat's softness and heating rate. Fluid release during heating commenced at about 10°C below the softening point of the fat and the temperature at which fluid loss commenced rose with the increase in solid fat content (SFC). Lee *et al.* (1981c) also suggested that emulsions prepared with soft fats (SFC around 20% at 70°C) was thermally less stable unless fat is dispersed uniformly throughout the matrix.

Unlike medium hard fat, soft fat was not uniformly dispersed during comminution. Stable emulsions were obtained when dispersions were prepared with fat containing 30% solid at 16% product fat level, 40% solid at 22% level, and 50% solid at 28% level (Lee *et al.* 1981c). In margarine, the fat blend is designed to have SFC of less than 3% at 35°C for clean melting in the mouth (Gunstone 1996). Thus, the high SFC values and softening points (>50^{0}C) in soy-based plastic fats studied might render them impractical to be incorporated into meat products.

Studies on replacement of animal fat with palm oil products in beef burgers were reported by Babji *et al.* (1998) and Shiota *et al.* (1995). The potential of palm fat to replace animal fat in processed meats seems promising. The physicochemical characteristics of palm fractions can be tailored to imitate functional properties of various animal fats. Moreover, palm oil also possesses several important physical properties and benefits which include high stability to oxidation; natural solids content; stability in the beta prime crystalline form; ready and increasing availability worldwide; competitive priced, nutritionally healthy and balanced composition (Anon 1991). Therefore, the objectives of the present study were to investigate various palm fats and palm olein, and level of fats on the thermal stability of chicken frankfurters.

MATERIALS AND METHODS

Experimental Design

The design consisted of a 4 x 2 factorial arrangement with the factors being types of fat (PF60:40, PF70:30, PF80:20 and palm olein) and levels of fat (20% and 25%).

Materials

Three types of palm fats with different ratios of palm stearin (POs): palm oil (POo) at 60:40, 70:30 and 80:20 were provided by the Malaysian Palm Oil Board (MPOB). Palm olein (PO_o) with the brand name Sawit Emas was obtained from a local retailer. Chicken trimming was purchased from Dinding Poultry Sdn. Bhd., Setiawan, Perak.

Formulation

Formulations for chicken frankfurters are shown in Table 1.

Processing

Frozen chicken trimming was manually cut into 2 cm^3 cubes and minced through a 4 mm-diameter grinder plate. The minced chicken trimming was stored at -18^{0}C until used. Before the actual frankfurter processing, pre-emulsion was prepared. Isolated soy protein (ISP) was chopped with palm olein (POo) or palm fats (PF) and water at a ratio of 1: 5 :5 (w/w/w) with a mixer (Hobart Ditosama). The ISP-water mixture was chopped for 4 minutes. Due to the difference in physical state between POo and PF, the chopping time after fat incorporation also varied. The pre-emulsions of POo and PF were further mixed for 3 and 7 min, respectively, after the addition of fats. The pre-emulsions were kept in a chiller until used.

Before processing, dextrose, phosphate, chicken flavour, sodium erythrobate, pepper and curing salt were diluted in iced water. Salt was added to frozen minced chicken trimming (CT), and chopped in a mixer (Hobart Ditosoma) for 4 min. Pre-emulsion and part of the iced water mixed with various ingredients were then added and chopping continued for another 1 min. Chopping was carried on for another 1 or 3 minutes after the remaining POo or PF was added. The remaining ingredients, namely potato starch, corn syrup and iced water mix were added to the meat batter and chopped for another 2 min to ensure a thorough mixing and to obtain a homogenised meat batter. Temperature of meat batters was recorded at the end of blending.

TABLE 1
Formulations for chicken frankfurters

Ingredient	Composition of meat batters (%)	
	20% Fat level	25% Fat level
Chicken Trimming (CT)	44.19	39.19
Palm fats with PO:POs =60:40, 70:30, 80:20 or palm olein	20.00	25.00
Iced water	25.71	
Soy protein isolate (ISP)	1.78	
Chicken flavour	1.78	
Salt	0.49	
Golden syrup	1.20	
Dextrose	1.00	
Phosphate	0.49	
Pepper	0.33	
Curing salt	0.01	
Sodium erythrobate	0.02	
Potato starch	3.00	

Emulsion Stability

The emulsion stability for meat batter was determined by using the combined and modified method of Miller *et al.* (1968) and Decker (1985) as described by Seri Chempaka *et al.* (1996). A

10 g sample of frankfurter batter was placed on a coiled wire attached halfway to a graduated glass cylinder (2 cm x 11.5 cm) and covered with aluminium foil. The samples were cooked in a closed water bath of 70°C for 60 min. The level of water in the water bath covered $\frac{3}{4}$ of the tubes. The coils and samples were removed and the weight of the released liquid was recorded (w). Emulsion stability was calculated as:

$$ES(\%) = \frac{w}{20} \times 100\%$$

Water Holding Capacity

Water holding capacity (WHC) was determined by the modified technique of Wierbicki (1957). Approximately 20 g of the sample were homogenised with 40 ml of distilled water. Ten grams of homogenate were weighed and put into a graduated centrifuge tube. The homogenate was centrifuged at 2000 rpm for 5 min. The volume of insoluble protein (v) was recorded, and WHC(%) was calculated as shown below:

$$\% \text{ WHC} = v / 10 \times 100\%$$

Iodine Value, Slip Melting and Solid Fat Contents of Palm Fat

Iodine values (IV) and slip melting points (SMP) of palm fats were determined by Wij's and Capillary tube methods (Siew *et al.* 1995), respectively. Solid fat content (SFC) of palm fats was measured by 'wideline nuclear magnetic resonance (NMR) Bruker NMS120 Minispec Analyzer' using the PORIM parallel method (Siew *et al.* 1995).

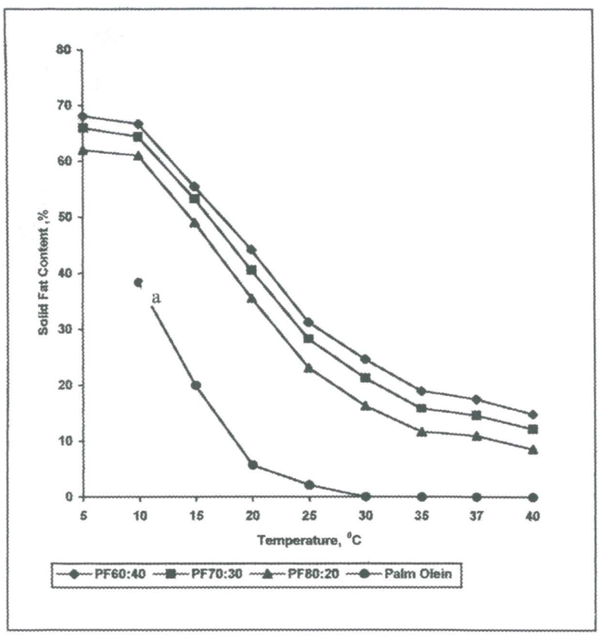
Statitiscal Analysis

Data collected from this study were analysed using PC-SAS version 6.04. If F value was significant, comparison of means by Duncan multiple range test (Cody and Smith 1991) was subsequently carried out.

RESULTS AND DISCUSSION

Physical Characteristics of Palm Fats and Palm Olein

The physical characteristics of palm fats (PF) and palm olein (POo) are shown in *Fig. 1* and Table 2. The slip melting points (SMP) increased while iodine value (IV) decreased along with the



[a] The SFC value of palm olein (POo) is quoted from Siew (1998)

Fig. 1. Effect of heating on the solid fat content (SFC) of various palm fats and palm olein

TABLE 2
Slip melting point (SMP) and iodine value (IV) of various palm fats and palm olein

	Palm fat (Palm oil : Palm stearin)			POo [a]
	PF60:40	PF70:30	PF80:20	
SMP (°C)	49.1	47.3	45.5	21.5
IV	44.7	46.5	49.0	56.8

[a] The values of SMP and IV of palm olein (POo) are quoted from Siew (1998)

increment of stearin in PF. The IV measures the content of unsaturation or double bonds capable of reaction with halogen, and it is a good index of the degree of unsaturation in fat products. The solid fat content (SFC) of PF at various temperatures was measured and monitored at different temperatures to give a plot of percentage of solid against temperature (*Fig. 1*). The slope of this curve and the temperature at which there is no solid phase provide useful information about the melting and rheological behaviours of the fat under investigation (Gunstone 1996). Solids remaining at the mouth temperature give a feeling of 'waxiness' to the product and these properties are important in confectionery and in spreading fats (Gunstone 1996). In this study, higher SFC was observed for palm fats with a greater proportion of palm stearin at any given temperature. At body temperature (37°C), SFC for the PF60:40, PF70: 30 and PF80:20 was 17.5%, 14.6% and 10.9%, respectively. It is uncertain whether the same "mouth-coating" effect of high SFC in confectionery and spreading fats will also be applied in meat products, especially comminuted meat products where fat has been finely distributed and emulsified. As more and more research focuses on fat substitution in meat products using various kinds of fat, the role of SFC should be investigated further, especially with regard to the physical and sensory attributes of the meat products.

Effects of Type and Level of Palm Fats and Palm Olein at Chopping Temperature

The final temperature of the meat batters at the end of comminution is shown in Table 3. Final chopping temperatures of meat batters containing palm fat PF60:40 and palm olein (POo) were significantly lower than those of PF70:30 and PF80:20 at 20% fat level. Effects of rising fat concentration on final chopping temperatures appeared unclear as no clear trend was shown from the data obtained. The final chopping temperature of meat batters containing POo at 25% was the lowest among all formulations tested. In processing comminuted meat products, temperature of meat products should be kept as low as possible to avoid denaturation of meat protein. Halmer and Saffle (1963) studied the effects of chopping temperatures on emulsion stability and reported that breakdown occurred in emulsion chopped to 16°C or higher. Utilisation of solid PF was found to affect the processing behaviour of frankfurters. A longer time was needed and more energy was generated in order to finely comminute and disperse the PF. Consequently, meat batters prepared

TABLE 3
Final chopping temperature, emulsion stability and water holding capacity of meat batters as influenced by the addition of different types and amounts of palm fats and olein

		Palm fat(Palm oil : Palm stearin)[f]			POo [f]
		PF60:40	PF70:30	PF80:20	
Final chopping	20%	20.0[b y]	23.3[a x]	23.7[a x]	20.0[b x]
Temperature (°C)	25%	25.0[a x]	20.0[c y]	23.3[b x]	18.5[d y]
Emulsion stability	20%	0.00[b y]	2.44[a x]	0.00[b x]	0.00[b x]
(% Fluid loss)	25%	3.95[a x]	1.49[b x]	3.90[a y]	0.25[b x]
Water holding	20%	38.0 [c x]	64.3[a x]	59.5[b x]	34.3[d x]
Capacity (%)	25%	33.5[c y]	62.7[a x]	45.5[b y]	21.3[d y]

[a-d] Mean values within the same row bearing different superscripts differ significantly (P<0.05)
[x-y] Mean values within the same column bearing different superscripts differ significantly (P<0.05)
[f] Fat used for frankfurter processing: PF = Palm fat; POo = Palm olein

with PF had generally recorded higher chopping temperatures compared to the ones containing POo. Besides raising the chopping temperature, the addition of PF also elevated the viscosity of meat batters. Meat batters containing PF were observed to be thicker than those of POo. Thicker meat batter is problematic during processing, because low flow-ability of meat batter results in low recovery, machine jamming, stuffing difficulty and overall poor handling. The impaired appearance of frankfurters such as holes at the surface and loose skin after cooking might be due to insufficient meat content in casings or to the possibility that the meat was not compact enough during stuffing.

Emulsion Stability

The emulsion stability of meat batters is shown in Table 3. Emulsion stability is used to determine the fat and water binding ability of the batter and is crucial to frankfurter production. At 20% fat concentration, meat batters mixed with PF60:40, PF80:20 and POo exhibited no fluid loss after heating. Fluid loss of meat batters containing 25% of PF60:40 and PF80:20 were the highest among all formulations and were significantly different from that of POo at the same level. The difference in emulsion stability between solid fat (PF) and liquid oil (POo) may be due to the difference in physico-chemical properties of fat and final chopping temperature (Webb *et al.* 1975). Lee *et al.* (1981b) studied the microscopic structure of meat batters prepared from plastic fats, and reported that emulsion breakdown at high chopping temperature is a consequence of increased fat mobility after softening. Beyond the softening point of fat, its mobility overcomes the ability of the protein matrix to maintain uniform fat distribution by restraining fat coalescence. Between the cooking temperature range of 43 to 70°C, the fat within the protein lattice is in an expanding liquid form while the proteinaceous shell surrounding it is in a semi-solid rigid state (Jone & Mandigo 1982). Cooking would then cause fat to separate from the matrix and fat coalescence occurs, developing interstitials causing a discontinuity of matrix. Fluid loss of meat batter incorporated with liquid oil at both fat levels were extremely low indicating a very stable emulsion. In contrast with PF, POo had exhibited the maximum mobility during addition. Thus, it is envisaged that a different mechanism had taken place in the stabilisation of meat batters containing different types of fat. The hypothesis proposed by Lee *et al.*(1981b) might be well suited for meat batters prepared with plastic fats, such as palm fats in this study. Initial and total emulsification of fat droplets, together with protein entrapment do play important roles in the stabilisation of meat emulsion containing liquid oil and plastic fat. As plastic fats melt within a wide temperature range, effect of initial emulsification and protein entrapment ceased as temperature rose. Melted fat coalesced and eventually led to the disruption the meat emulsions, resulting in emulsion breakdown.

Water Holding Capacity

Contrary to the result of emulsion stability, water holding capacity (WHC) of meat batters containing palm fats (PF) were higher than meat batters containing palm olein (POo) ($P<0.05$) (Table 3). WHC of meat batters formulated with PF60:40, PF80:20 and POo decreased when fat content was raised from 20 to 25%. WHC of meat batters containing POo was observed to be the lowest for both fat levels. Determination of centrifuge loss in unheated meat, as in the determination of WHC, belongs to a group of measurements using mechanical force and is dependent on the plasticity of the meat. Meat that is soft and easily compressed by centrifugal force will express more juice than a solid, inflexible material (Honikel 1987). Therefore, the soft batter of POo showed a lower reading in total insoluble protein compared to those of PF. Meat batters containing 20% fat were observed to retain more water than batters with 25% fat. This might be due to the fact that further addition of 5% extra fat had overloaded the meat protein's ability to bind water and fat. When mechanical forces, such as centrifugation are subjected to the mixture, the loosely bound water and fat will be released and therefore, less water will be entrapped within the protein portion.

CONCLUSION

Palm olein shows a greater potential to substitute animal fat in chicken frankfurters as it possesses no manufacturing problem and results in a more stable meat emulsion compared to the various palm fats tested. Low recovery and defective products are among problems encountered when palm fats were to totally substitute animal fat. The plasticity and a wide melting temperature range of palm fats caused difficulty in chopping and resulted in lower quality meat products. Further research is being carried out to improve the quality of the frankfurters so that palm olein blended frankfurters can be as good as or better than conventional frankfurters.

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