

Special Palm-based Fat Spread for Bakery Frozen Dough

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INTRODUCTION

Frozen dough, as a new ingredient for the production of bread, has been developed along with other innovations in the baking industry. Due to its convenience, affordability and consistently high quality, frozen dough has rapidly become popular in the world since the 1950s. Nowadays, frozen dough occupies a substantial proportion of the food market, including supermarkets, restaurants, institutions and the catering business. The bread bakery industry is increasingly using frozen dough, especially in line with the development of bread store chains. Bread baked from frozen dough is gaining popularity in USA and Japan, with market shares of 80% and 50%, respectively, of the local bread markets. In China, the bakery industry has expanded rapidly in recent years with an annual throughput of 1.6 million tonnes of bakery products in 2006, although its development is still in its infancy. In view of this, the market for frozen dough in China has an excellent growth potential with the mushrooming of bread store chains in the country. Currently, many large Chinese bread store chains are using frozen dough for their bakery products.

Oils and fats are important ingredients of frozen bread dough and they have profound effects on the product quality and storage stability. Currently, hydrogenated oil, normal shortening and margarine are usually used in frozen bread dough in China. The objectives of this study were to prepare a special palm-based fat spread for frozen bread dough and to evaluate its performance.

MATERIALS AND METHODS

Materials

Refined, bleached and deodorized (RBD) palm oil was obtained from Dongma Oils & Fats Co., Ltd., while refined soyabean oil was provided by Shanghai Kerry

& Grains Industry Co., Ltd. High protein flour was obtained from Zhengzhou Haijia Food Company. Sugar, skimmed milk powder, salt and dry yeast used in the experiments were all of food grade. The emulsifiers used were sucrose fatty acid ester [(SE) HLB=11] and Tween 80 (HLB=15), and the enzyme used was PPL (Porcine Pancreas Lipase). The commercial oil used in the frozen bread dough was provided by Luohe Shuanghui Grease Industry Co., Ltd.

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Experimental Methods

Interesterification (IE) of palm stearin (POs) and soyabean oil (SBO) – IE (POs:SBO). Palm stearin and soyabean oil were interesterified using an alkali catalyst. Palm stearin (140 g) and soyabean oil (60 g) were mixed and heated under vacuum. The catalyst (NaOH and glycerol at a ratio of 1:1) at 1.5% of oil weight was added. The reaction was carried out at 140°C for 45 min and at a pressure of 80 pa. The reaction products were washed with aqueous citric acid solution until neutral, and then dried under vacuum.

Preparation of the oil-in-water (O/W) special palm-based fat spread (Inoue et al., 1995). The special palm-based fat spread for frozen bread dough was prepared using IE (POs:SBO) as the raw material. The production process of the oil-in-water (O/W) type emulsified product was as follows:

Water ← Emulsifier

↓

Oil → Mix → Pre-heat → Emulsify → Quench → Age → Finished product

The emulsifiers were dissolved in water and were mixed with the IE (POs:SBO). The whole mixture was heated to 75°C and then emulsified for 1 min. The emulsion was then quenched in an ice bath for 5 min and aged at 25°C for 24 hr.

When preparing the oil-in-water special spread, the following parameters were studied: the amount of emulsifiers used, emulsification temperature, emulsification time and the oil-water ratio. Details are as follows:

- the amount and the ratio of emulsifiers: Tween 80 and SE were selected as the emulsifiers for the formulation. The ratios of Tween 80 and SE studied were 4:1, 3:1, 2:1, 1:1, 1:2 and 1:3 and the amount of mixed emulsifiers were 4%, 6%, 8%, 10%, 12%, 14% and 16%;
- emulsification temperatures: 60°C, 65°C, 70°C, 75°C and 80°C;
- emulsification times: 0.5 min, 1 min, 3 min, 5 min, 10 min, 15 min and 20 min; and
- oil-water ratios: 4:4, 4:5, 4:6, 4:7 and 4:8.

Orthogonal experiments were carried out based on the above results to optimize the emulsification parameters.

Preparation of the bread dough using the special fat spread. The frozen bread dough was made based on the formulation shown in Table 1.

The flour, salt, sugar and skimmed milk powder were placed into a dough kneading machine. Dry yeast dissolved in water was then added. The whole mixture was kneaded for 6 min. The ready

dough was spread out evenly and placed in a refrigerator and kept at -40°C for 30 min. Finally, the frozen dough was maintained at -18°C or lower at all times.

Baking Frozen Bread Dough

The baking process for the frozen bread dough was carried out as follow (GB/T 14611-1993):

Frozen dough → Thawing → Kneading → First fermentation → Shaping → Second fermentation → Baking

Conditions for the various unit processes were as follows:

- thawing: temperature 32°C, relative humidity 75%, thawing time 75 min;
- kneading: the dough was kneaded until smooth and non-sticky;
- first fermentation: temperature 32°C, relative humidity 75%, time 90 min;
- second fermentation: temperature 32°C, relative humidity 75%, thawing time 60 min; and
- baking: oven temperature 180°C to 200°C, baking time 20 min.

Analytical Methods

The following analyses were carried out:

- acid value (GB/T 5530-1998);
- iodine value (GB/T 5532-

1995);

- peroxide value (GB/T 5538-2005);
- moisture and volatile substances (GB/T 5528-1995); and
- solid fat content (AOCS, 1999).

Determination of Emulsion Stability

The special spread (10 g) was placed in a 10-ml centrifuge tube and heated in a water bath (70°C) for 60 min. The sample was then centrifuged for 10 min at 3500 rpm. The height of the emulsified layer was recorded, and the emulsion stability was calculated using the following formula:

$$\left(\text{Emulsion stability} = \frac{\text{Height of emulsifier layer}}{\text{Liquid height in centrifuge tube}} \times 100\% \right)$$

Hydrophilic-lipophilic Balance (HLB) Value of the Compound Emulsifier. The HLB value of the compound emulsifier was calculated using the following formula:

$$H_r = \frac{W_a \times H_a + W_b \times H_b}{W_a + W_b}$$

where:
 W_a = mass fraction of emulsifier a;
 W_b = mass fraction of emulsifier b;
 H_r = HLB value of compound emulsifier;
 H_a = HLB value of emulsifier a; and
 H_b = HLB value of emulsifier b.

TABLE 1. FORMULATION OF FROZEN BREAD DOUGH

Component	Flour	Salt	Sugar	Dry yeast	Skimmed milk powder	Water	Special fat spread
Quantity	100 g	1.5 g	6 g	1.6 g	4 g	60 ml	6% (of flour weight)

RESULTS AND DISCUSSION

Analysis of Physico-chemical Parameters – Acid Value, Iodine Value, Peroxide Value, Moisture Content and Melting Point of Raw Materials

Palm stearin and soyabean oil were blended in the ratio of 70:30. The acid value (AV), iodine value (IV), peroxide value (PV), moisture content and melting point (MP) of the blended oils before and after IE were determined, and results are shown in *Table 2*. The results show that the IV of IE (POs:SBO) was not very different compared to the IV of POs + SBO before IE. The IE reduced the MP of the blended oil from 51°C (before IE) to 42°C (after IE).

Solid Fat Content

The blended oil before IE and after IE was analysed for solid fat content (SFC) and the results are shown in *Figure 1* which shows that the SFC of the interesterification has lower the SFC of the blend.

The IV and MP of oils/fats have profound effects on their applications. Those with a very low melting point (hence high IV) tend to be liquid, and by contrast, those with a high MP (say >50°C) tend to be hard and solid, and will not yield good results when used for making

frozen dough. Data in *Table 2* show that IE of POs:SBO (70:30) resulted in a soft solid fat product with a melting point of 42°C, which was much lower compared to the original palm stearin. The lower IV of about 66.7 of the blend was expected, falling between that of palm stearin and soyabean oil. In our experiment, this special IE fat blend with low SFC of about 18% was found to be suitable for the preparation of frozen dough.

Formulation of O/W Special Fat Blend

Effect of the ratio of emulsifiers on emulsion-stabilizing property. The effect of the ratio of the compound emulsifiers on the emulsion-stabilizing property was studied. The reaction conditions were as follows: temperature of 70°C, emulsification time of 1 min, oil-water ratio of 4:6, and the amount of compound emulsifier was 12% of the gross weight. The results are shown in *Figure 2*.

It can be seen from *Figure 2* that the emulsion-stabilizing property exceeded 90% when the emulsifier ratio was at 2:1 and 1:1, respectively. As Tween 80 emulsifier has the properties of increasing foaming and flavour, a lower level of Tween 80 would be better for the emulsion. Meanwhile, the HLB of Tween 80 and SE were 15 and

11, respectively, and that of the compound emulsifier at the ratio of 1:1 was 13. Considering the characteristics of the emulsifiers, especially that of Tween 80, the optimum ratio of the compound emulsifier that was selected was 1:1, although the observed emulsion-stabilizing property was highest when the ratio of Tween 80 and SE was 2:1.

Effect of the Amount of Compound Emulsifier on Emulsion-stabilizing Property

Figure 3 shows that the emulsion-stabilizing property improved with an increase in the amount of emulsifier. When the amount of emulsifier was increased to 12%, the emulsion system was most stable.

Effect of Emulsification Temperature on Emulsion-stabilizing Property

Figure 4 shows that when the temperature was below 75°C, the emulsion-stabilizing property increased with increasing temperature. However, when the temperature exceeded 75°C, the emulsion-stabilizing property decreased with subsequent increases in temperature. The optimum temperature was thus 75°C.

TABLE 2. PHYSICO-CHEMICAL PARAMETERS OF OILS BEFORE AND AFTER INTERESTERIFICATION (IE)

	Physico-chemical index				
	Acid value (mg KOH g ⁻¹)	Moisture content (%)	Iodine value (g I ₂ / 100 g)	Peroxide value (mmol kg ⁻¹)	Melting point (°C)
Palm stearin (POs)	0.28	0.03	30.72	2.07	55
Soyabean oil (SBO)	0.11	0.02	131.83	1.90	-
70 POs: 30 SBO	0.22	0.03	66.65	1.72	51
IE (POs:SBO = 70:30)	0.11	0.01	66.74	1.24	42

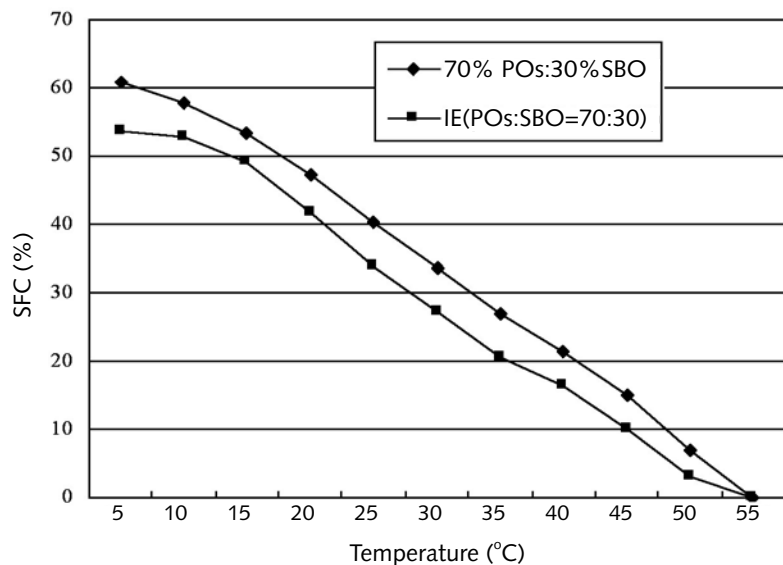


Figure 1. Solid fat content (SFC) of the blended oil (70% POs:30% SBO) and interesterification (IE) (70% POs:30% SBO).

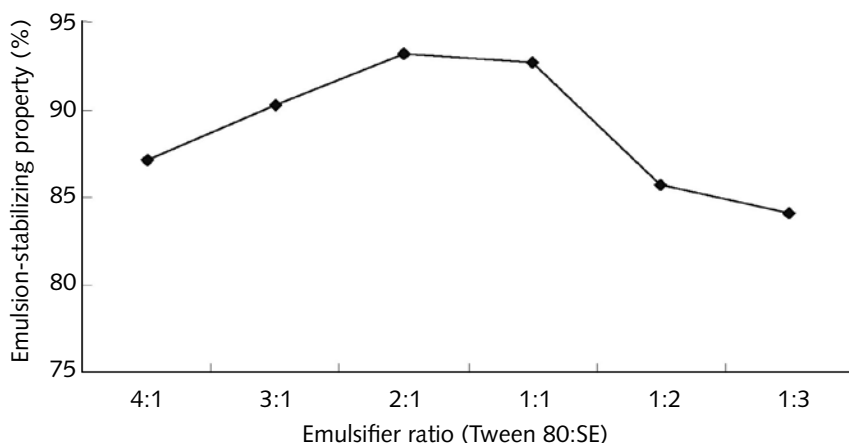


Figure 2. Effect of emulsifier ratio on emulsion-stabilizing property.

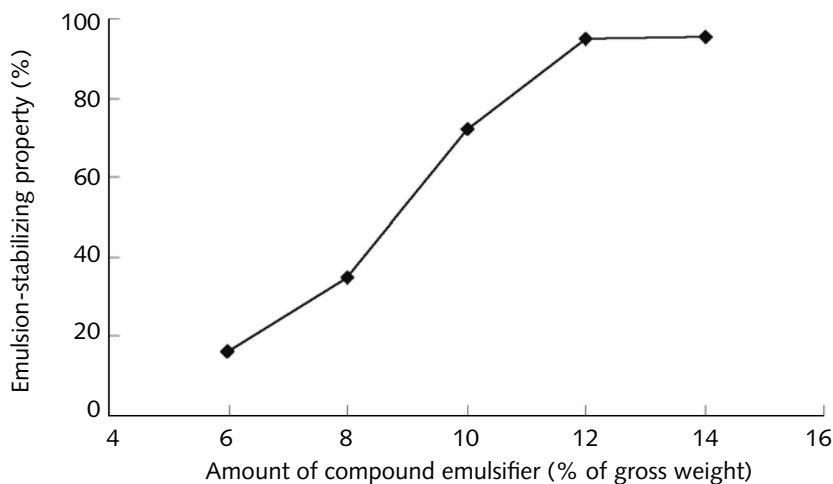


Figure 3. Effect of amount of emulsifier on emulsion-stabilizing property.

Effect of the Emulsification Time on Emulsion-stabilizing Property

Figure 5 shows that the emulsion-stabilizing property increased rapidly within the first minute. When the emulsification time was increased from 1 min to 5 min, the emulsion system collapsed and the emulsion-stabilizing property decreased with further increases in time, stabilizing after 10 min. The optimum emulsification time was thus 1 min.

Effect of the Oil-water Ratio on Emulsion-stabilizing Property

Figure 6 shows that the emulsion was more stable with an increase in the proportion of the water phase. The system was most suitable when the oil-water ratio reached 4:6. When this ratio exceeded 4:6, the emulsion became less stable.

Optimization of the Formulation of Special Fat (O/W) Blend

An orthogonal experiment was carried out to optimize the emulsification parameters. The levels of the orthogonal experiment were selected based on the above single factor experiments (Table 3). The results from the orthogonal experiment and the ANOVA of the results are shown in Tables 4 and 5, respectively.

Optimization of emulsification process obtained from the orthogonal experiment was $C_3A_2B_3D_2$, i.e. the amount of emulsifier was 12%, emulsification time was 1 min, emulsification temperature was 75°C and the oil-water ratio was 4:6. The emulsion-stabilizing property of the special palm-based fat spread made under the

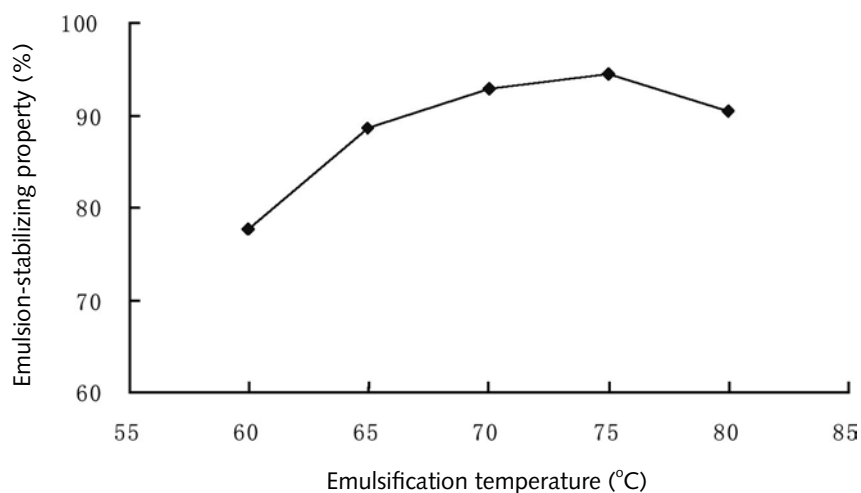


Figure 4. Effect of emulsion temperature on emulsion-stabilizing property.

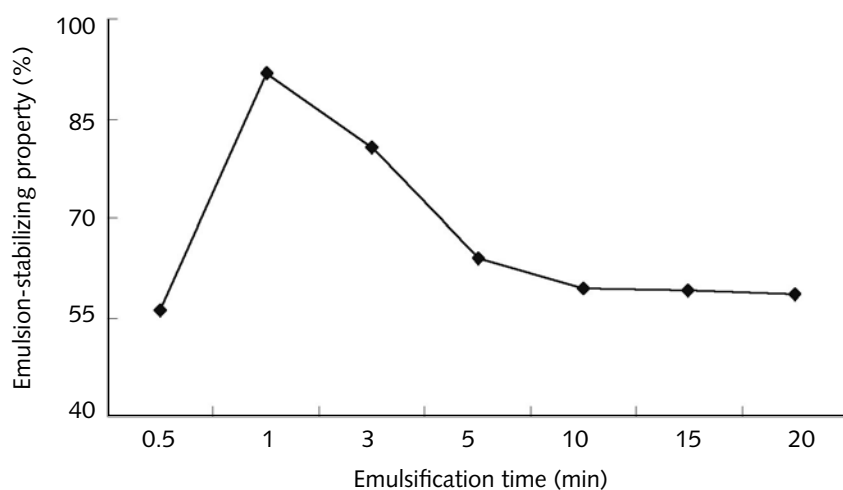


Figure 5. Effect of emulsion time on emulsion-stabilizing property.

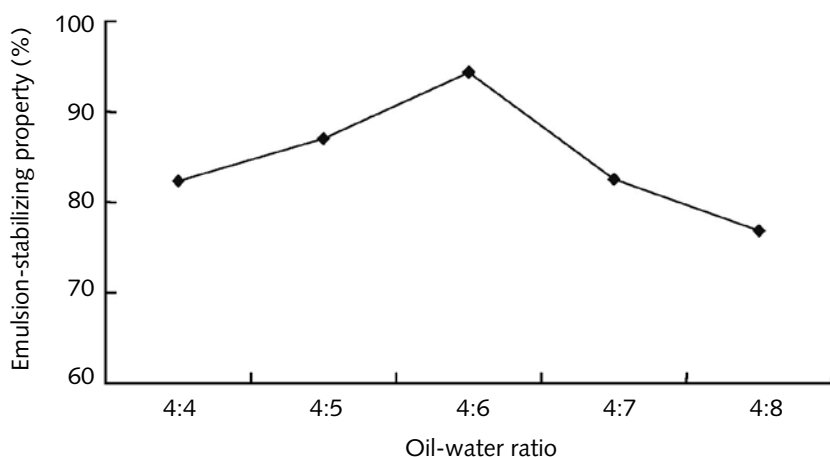


Figure 6. Effect of oil-water ratio on emulsion-stabilizing property.

optimized emulsification process reached 95%. The image of this special fat observed under the XP-200E polarizing microscope at 400X magnification is shown in *Figure 7*. The special fat (O/W) emulsion system was uniform with distinct granules.

Quality Evaluation of the Frozen Bread Dough

The performance of the frozen bread dough made from the oil-in-water (O/W) palm-based fat spread and from a commercial fat product obtained by the same process in the laboratory was compared after baking. The bread made from the palm-based fat spread had large volume, exquisite texture and was acceptable, and was comparable to that made from the commercial fat product as shown in *Figure 8*.

Data in *Table 6* indicate that the quality of frozen dough bread made from the special palm-based fat spread was better than that made from the commercial fat product.

CONCLUSION

Results of this research indicate that the processing properties of palm stearin can be improved by IE with soyabean oil at a suitable blend ratio. The O/W special palm-based fat spread made by IE of palm oil has advantages of lower calorie content and *trans*-free, having simple and good process ability and can be used for replacing hydrogenated oil in frozen bread dough. In the next stage of this research project, the nutritional attributes and organoleptic properties of the special palm-based fat spread will be studied.

TABLE 3. LEVELS OF ORTHOGONAL FACTORS

Level	Factor			
	Emulsification time (min)	Emulsification temperature (°C)	Amount of compound emulsifier (% gross weight)	Oil-water ratio
	A	B	C	D
1	0.5	65	8	4:5
2	1	70	10	4:6
3	3	75	12	4:7

TABLE 4. RESULTS OF ORTHOGONAL EXPERIMENT

Sample No.	Level				Emulsion-stabilizing property (%)
	A	B	C	D	
1	1	1	1	1	31.11
2	1	2	2	2	76.74
3	1	3	3	3	90.65
4	2	1	2	3	89.47
5	2	2	3	1	94.32
6	2	3	1	2	60.87
7	3	1	3	2	92.68
8	3	2	1	3	27.96
9	3	3	2	1	81.52
K ₁	66.06	71.09	39.98	69.33	-
K ₂	81.90	66.68	82.58	76.76	-
K ₃	67.39	77.57	92.78	69.25	-
R	15.84	10.89	52.80	7.51	-

Note: $K_n = \sum V_n / 3$; ($n = 1, 2, 3$); $R = K_{\max} - K_{\min}$.

TABLE 5. ANOVA (analysis of variance) OF THE ORTHOGONAL TEST RESULTS

Factor	Square of deviance	Degrees of freedom	F-ratio	F critical value	Significance
A	463.22	2	4.15	19	ns
B	179.94	2	1.61	19	ns
C	4706.88	2	42.12	19	s
D	111.76	2	1.00	-	ns
Error	111.76	2	-	-	-

Note: Square of deviance = $\sum (X_i - \bar{X})^2$ (Remark: mean square = square of deviance/degrees of freedom).
 ns - not significant.
 s - significant.

TABLE 6. QUALITY EVALUATION OF BAKED FROZEN DOUGH BREAD MADE FROM COMMERCIAL FAT AND FROM SPECIAL PALM-BASED FAT SPREAD (GB/T 14611-1993)

Oil/fat used in frozen dough	Height after thawing (cm)	Height after baking (cm)	Specific volume of bread (ml g ⁻¹)	Sensory evaluation (p+s)
Commercial fat product	2.75	7.3	4.12	73.5
Special palm-based fat spread	2.75	7.4	4.21	75.5

Note: Specific volume of bread (ml/g) = bread volume (ml)/bread quality (g).

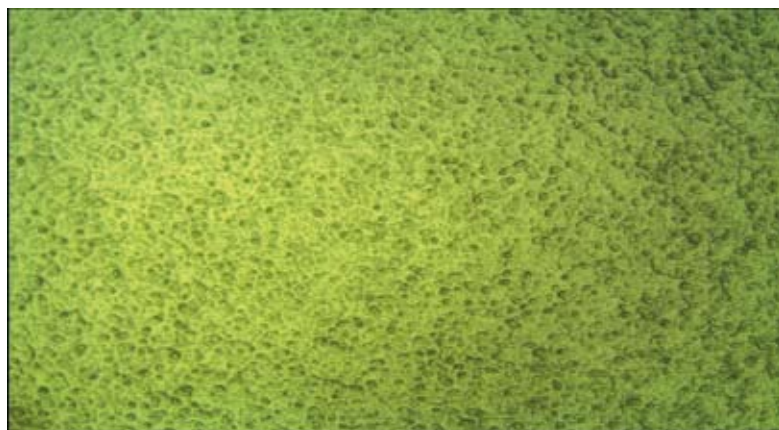


Figure 7. Special palm-based fat spread system observed under a polarizing microscope.



Figure 8. Frozen dough bread made from commercial fat (left) and from O/W special fat spread (IE) (right).

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