Palm-Based Shortenings Suitable for Indian Market

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INTRODUCTION

Shortening is a typically 100% fat product formulated with animal and/or vegetable oils that have been processed for functionality. Shortening is used in frying, cooking, baking, and as an ingredient in fillings, icings, and confectionery items. In recent years, there have been numerous calls for functionally superior, cost effective fats which can be effectively used in applications requiring thermal stability (for example, deep frying and applications requiring plasticity (for instance, baking) (Kiley *et al.*, 1996).

PRODUCTION OF SHORTENINGS

Traditional fats used in the baking industry include lard, tallow and butter. However, there is a trend towards utilization of vegetable oil based shortenings due to nutritional and economic considerations. Since the twentieth century, there has been a steady conversion from animal-based to partially hydrogenated vegetable oil-based shortenings. Users can have greater control over shortening functionalities and are able to mitigate the price fluctuations associated with animal fats which is subject to livestock prices.

Shortenings can be considered an American invention, and the data in *Table 1* confirm that North America is the world's largest producer of shortenings (Anon, 1993). The data show that world shortenings production has been stable at about four million tonnes per year since 1990, with North America being responsible for about half of this.

TYPES OF SHORTENINGS

Shortenings may be classified on the basis of their chemical or physical characteristics, raw materials from which they are made or their intended application. Solid shortenings are classified according to their plasticity range. A shortening with a narrow plasticity range is hard at low temperatures and soft and practically fluid at high temperatures. Shortenings in this category have high stability and are used for deep frying and in confectionery products. On the other hand, a shortening with a wide plasticity range has a flat solid fat content (SFC) curve. All-purpose shortenings are in this category and contain 15%-30% solid fat and retain many of these solids over their intended temperature usage.

Liquid pourable shortenings include clear oils as well as fluid or opaque types. Pourable shortenings contain low solids levels with very flat SFC profiles. Specialty shortenings may be of any general type depending on the requirements for specific application, and their SFC profiles will be characteristic of that particular type.

Spray dried powdered shortenings are partially hydrogenated shortenings encapsulated in water-soluble materials. They are used in some prepared mixes for their ease in blending with the other dry ingredients.

APPLICATION OF PALM OIL IN SHORTENINGS

Most shortenings are identified and formulated according to their usage. Raw materials selection for shortenings has been

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influenced by availability and economics. These factors were the main reasons for the development and introduction of vegetable oils-based shortenings. Palm oil became a major source oil for U.S. shortenings in the mid-1960s. Palm oil has been found to be an excellent plasticizing agent which stabilizes shortening's crystal habit in ß' form (D'souza *et al.*, 1990; Nor Aini *et al.*, 1995).

The use of palm oil can be maximized through modification processes. Besides fractionation, blending, hydrogenation and interesterification are common ways of modifying the characteristics of palm oil. Hydrogenation alters the characteristics of palm oil basically in three ways: (1) increases the melting range, (2) improves stability, (3) improves the rate of crystallization. In the hardening process, hydrogen gas is reacted with an oil at a suitable temperature and pressure in the presence of catalyst with agitation. Control of these conditions and the end point enables the operator to better meet the desired physical characteristics of the raw materials for shortening production.

Interesterification is a process that changes the natural distribution of fatty acids in triglycerides. This rearrangement affects the physical and functional properties of the oils or fats and is accomplished by a catalytic method at relatively low temperature. The use of palm oil fractions in shortenings can be maximized by interesterification.

CHARACTERISTICS OF PALM BASED SHORTENINGS

In many products, such as cakes, pie crusts, icings, cookies and other pastries, shortening is the major contributor to the product structure, eating characteristics and quality of the finished products. Satisfactory shortening performance is dependent on several factors such as (1) flavour (2) physico-chemical characteristics and (3) crystal structure.

Flavour

The flavour of a shortening should be completely bland so that it can enhance the food product's flavour rather than contribute a flavour of its own. In this respect, palm oil and its fractions are very suitable as they are bland when refined. Oxidative stability requirements of the finished product must be established to determine the minimum requirements of the shortening. The oxidative index of a shortening is directly related to the type and amount of unsaturated fatty acids available.

Physico-Chemical Characteristics

The characteristics of the fats and oils utilized in shortenings are of primary importance in the design of the shortening for a specific use. Oils can be modified through various processes to produce the desired properties. Hydrogenation has been the primary process used to change the physical characteristics of oils. Melting points or hardness of an oil can be completely altered through this process and the changes controlled by the conditions used to hydrogenate the oil.

In India, only palm olein or its derivatives is allowed to be used in edible applications. This paper provides data on the use of interesterified palm olein and hydrogenated palm olein as shortening suitable for the Indian market. Characteristics of these shortenings were evaluated. Normal palm olein and palm oil shortenings were included in the evaluation for comparison.

Table 2 shows physico-chemical characteristics of some palm based shortenings. Slip melting point ranged from 22.0°C to 38.8°C. Triglyceride composition showed that palm olein was high in C_{52} and C_{54} while interesterified palm olein, hydrogenated palm olein and palm oil were rich in C_{50} and C_{52} (*Table 2*). Interesterified palm olein also contained considerable amounts of C_{54}.

Crystal Structure

Each oil has an inherent crystallization tendency, either ß or ß'. The small, uniform, tightly knit ß' crystals produce smooth textured shortenings with good plasticity, heat resistance, and creaming properties. The large ß crystal tends to produce, brittle consistency shortenings that result in poor creaming properties and poor baking performance. However, the large ß crystals

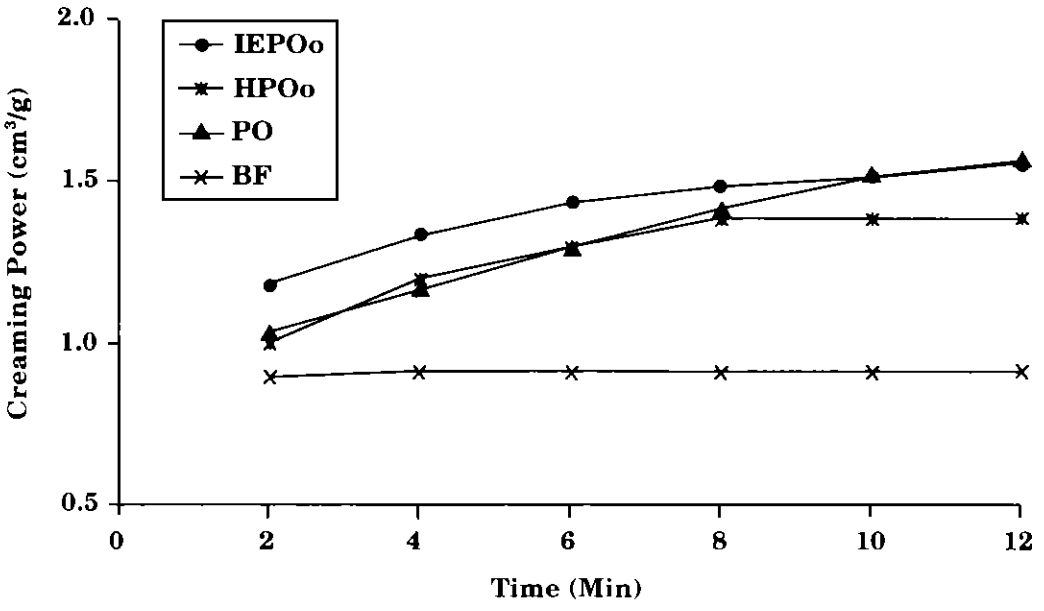

Figure 3. Creaming performance of some palm-based shortenings.

TABLE 3. CRYSTAL STRUCTURE OF SOME HYDROGENATED OILS AND FATS

ß'	ß
Palm oil	Palm kernel
Cottonseed oil	Canola oil
Butter oil	Cocoa butter
Herring oil	Coconut oil
Menhaden oil	Corn oil
Modified lard	Olive oil
Rapeseed oil	Lard
Tallow	Peanut oil
Whale oil	Safflower oil
	Sesame oil
	Soybean oil

Source: Wiedermann (1978).

are desirable for some applications such as pie crusts or for frying. The crystal habit of an oil or fat is determined by the following factors: content of palmitic acid, distribution and position of palmitic and stearic fatty acids on the triglyceride molecule, degree of hydrogenation and the degree of randomization. *Table 3* identifies the crystal habit of some hydrogenated edible oils (Wiedermann, 1978).

Many edible oil products contain various combinations of ß and ß' tending components. The ratio of ß-ß' crystals helps determine the dominant crystal but the higher melting triglyceride portions of a solidified fat product usually set the trend for the polymorphic behaviour of the crystallizing solids, (de Man and de Man, 1994). In addition, crystal habit is also influenced by processing conditions and tempering of the product.

PERFORMANCE OF PALM-BASED SHORTENINGS

Creaming Performance

The ability of a fat to incorporate air is an important factor in determining its value as a shortening agent. Air can be incorporated by beating a fat-sugar mixture

TABLE 4. FATTY ACID AND TRIGLYCERIDE COMPOSITION OF SOME PALM-BASED SHORTENINGS

Shortening	Palm olein	Interesterified palm olein	Hydrogenated palm olein	Palm oil
Fatty acid composition (wt% by GLC)				
C14:0	1.0	1.0	1.0	1.1
C16:0	39.8	37.1	37.6	42.1
C18:0	4.4	3.9	8.1	4.1
C18:1	42.5	44.9	—	41.3
C18:1t	—	—	13.9	—
C18:1c	—	—	33.9	—
C18:1i	—	—	3.1	—
C18:2	11.2	11.7	—	10.0
C18:2tc	—	—	0.2	—
C18:2ct	—	—	0.2	—
C18:2cc	—	—	0.7	—
Triglyceride composition (mole % by GLC)				
C44	—	0.6	—	—
C46	—	1.5	0.4	0.8
C48	2.3	8.9	2.9	7.4
C50	42.0	30.1	39.1	42.6
C52	45.7	39.6	44.9	40.5
C54	9.9	18.8	12.0	8.8
C56	—	0.1	0.4	—

TABLE 5. BAKING TEST FOR SHORTENING IN CAKES

Shortening	Specific cake volume E/C x 100
Interesterified palm olein	99%
Hydrogenated palm olein	97%
Palm oil	92%
Butter fat	91%

in a process known as creaming. Creaming properties of the fat can be determined by taking a specific volume of the fat-sugar mixture at specific intervals. Specific volume of the cream is expressed as volume per unit mass and is commonly known as creaming power. Creaming power of the palm-based shortenings evaluated ranged from 1.38 to 1.56cm^3/g after 12 min of beating (*Figure 3*), much higher than that of butter fat (0.91cm^3/g).

It has been suggested that creaming power is related to certain physical and chemical properties and crystal habit. Shortenings of good creaming properties are associated with ß' crystalline form. In this respect, palm oil is an excellent ingredient as it is ß' tending.

Baking Performance

The shortenings were evaluated for their performance in cakes using Madeira cake formulation. This particular formulation was chosen because it is low in fat content and therefore particularly sensitive to the properties of the fat. Performance of the experimental shortenings was compared with a standard shortening which was an international brand available in the supermarket and selected for its superior

TABLE 6. SPECIFIC VOLUME AND APPEARANCE OF BREADS MADE WITH PALM-BASED SHORTENINGS

Shortening	Specific volume (cmV/g)	Appearance
Interesterified palm olein	4.81	Uniform air cells
Hydrogenated palm olein	5.00	Air cells bigger in size
Palm oil	4.52	Good, small and even air cells

performance. The standard cakes were prepared using the same ingredients (except the fat) and baked at the same time side by side with the experimental cakes. Results showed that palm oil shortening performed slightly better than butter fat (*Table 5).* Hydrogenated palm olein produced higher cake volume than palm oil while interesterified palm olein produced the highest cake volume.

Table 6 shows that hydrogenated palm olein gave the highest specific volume of bread, followed by interesterified palm olein and then palm oil. Although bread made with palm oil shortening had a lower volume, it was of good quality as the air cells were small and even in size.

In applications such as pie crust where a grainy texture is desirable, shortenings having crystal in the ß polymorphic forms are recommended. In this case, a certain proportion of palm stearin is very suitable.

BENEFITS OF USING PALM OIL/ PALM OLEIN

1. It stabilizes the shortening in beta prime form, which is required for good performance.
2. It is very versatile and can be tailor-made to suit a particular application.
3. It is very stable and has a long shelf life due to the presence of vitamin E which acts as a powerful natural antioxidant.
4. Supply of palm oil/palm olein is abundant and consistent.
5. It is priced competitively.

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