Health and Nutritional Aspects of Palm Stearin: Perceptions and Facts

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INTRODUCTION

Among the dietary components, fats and oils have been the subject of much interest and debate because of their implications for maintenance of good health and association with risks for some diseases when consumed in excess. Since fats contribute to the energy density of foods, they have also been incriminated as a contributory factor in obesity. Arising from these concerns, considerable efforts have been expended in investigating the effects of fats and their component fatty acids on different aspects of human metabolism. The outcome has been a better understanding of fats and oils and thier effects in health and disease (Perkins, 1983; Nelson, 1990; Hui, 1996). However, the health risk factors related to fats are not entirely understood and much more research would be needed in the future to clarify some of these issues.

Fanctions of fats

Fats, besides being the most concentrated source of energy contribute to the palatability, flavour and to the satiety value of food. Fat is a carrier of the fat soluble vitamins A, D, E and K and the essential fatty acids, important in growth and in the maintenance of many body functions. Dietary fats are capable of acting on the composition, organisasion and functions of membranes. Fats are a major form of energy storage in the body *(Figure 1)*.

Requirements and sources of fats

Requirements for total fat itself may vary greatly depending on the physiological needs that are to be met. Palm oil and its products are able to contribute to the fat requirements of populations in many parts of the world.

Meeting edible oil needs

In terms of total consumption, palm oil makes up 17 % of the world consumption of 95 million tonnes, but in terms of its share of the worlds traded oils and fats, it has captured nearly 36%.

Malaysia, having emerged the number one producer of palm oil in the world, commands 52% of the total global production and 62 % of the world's exports today (Figure 2). With increasing future demand fueled by a rising world population, demand for oils and fats in the year 2005 is expected to rise to 125 million tonnes from the present 95 million tonnes (Varma, 1998).

Consumer awareness

The various benefits of palm oil including its proven quality and versatility in a wide variety of food and non food applications have been well documented through various research and development programmes. As a result palm oil is much sought after throughout the world. Despite much advances, there are some areas which remain controvesial, partly because palm oil and its products are relatively new comers to the oils and fats world market. There are concerns about palm stearin in some countries. Sometimes it is difficult to change deeply entrenched concepts in spite of the development of evidence to the contrary.

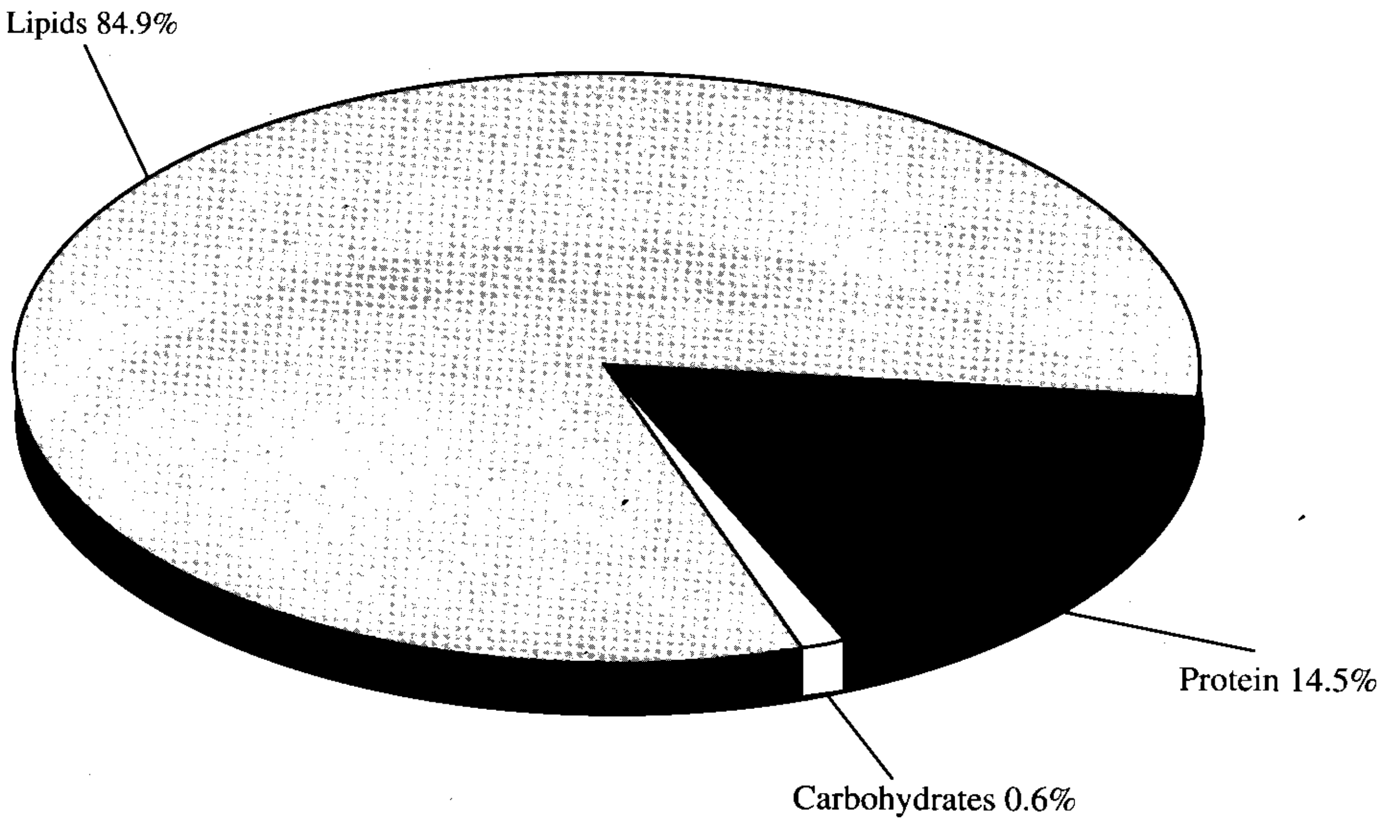


Figure 1. Energy Storage in "Normal" Weight Adults as % of Total Calories

Source: Masoro, EJ. Am J. Clin. Nutr., 30: 1311, 1977

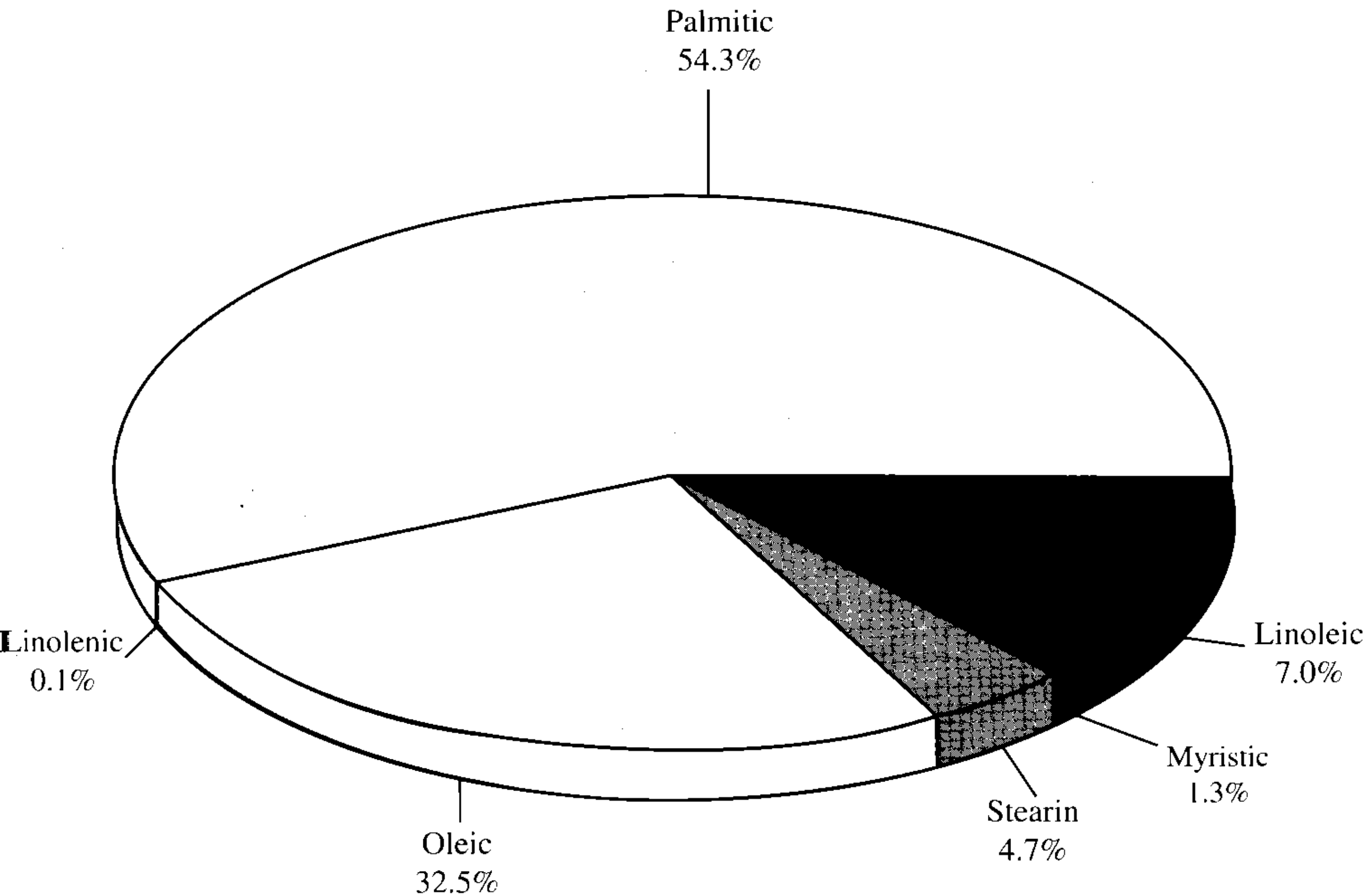


Figure 5. Fatty Acid Composition of Palm Stearin

TABLE 2. STEARIC ACID AND CHOLESTEROL CONTENT OF OILS AND FATS

Fat or oil	Stearic acid (% of total fatty acids)	Cholesterol (ppm)
Cocoa butter	34.5	59
Beef tallow	21.6	1100
Butter fat	12.5	3150
Lard	12.3	3500
Chicken	6.4	900
Soyabean oil	4.0	28
Coconut oil	2.3	14
Cotton seed oil	2.3	44
Mustard oil	0.5	-
Palm oil	4.7	16
Palm stearin	4.4 - 5.6	-

TABLE 3. STEARIC ACID CONTENT OF SELECTED FOODS

Foods	% Stearic acid
New Zealand lamb	6-10
Groundnuts	1.1
Sausages	3.7
Whole egg	3.2
Milk powder	2.9
Milk chocolates	8.6
Breast milk	7.00

drolysis of triacylglycerol. Lingual lipase has specificity for medium and short chain fatty acids. In the duodenum, the fat from the food is mixed with secretions of the bile duct including bile salts. Fat droplets are formed and the pH increases to 5.5-6.5. Pancreatic lipase is secreted and activated at that pH. Pancreatic lipase attacks triacylglycerol molecules at the surface of the large emulsion particles facilitated by bile salts. Pancreatic lipase preferentially releases fatty acids in the Sn-1 and Sn-3 positions and this produces fatty acids and 2 monoglycerides.

Digestion of triacylglycerols in the intestinal tract is a series of stepwise reactions from triacylglycerols to 1,2 diacylglycerols to mono acylglycerols with fatty acids released at each step.

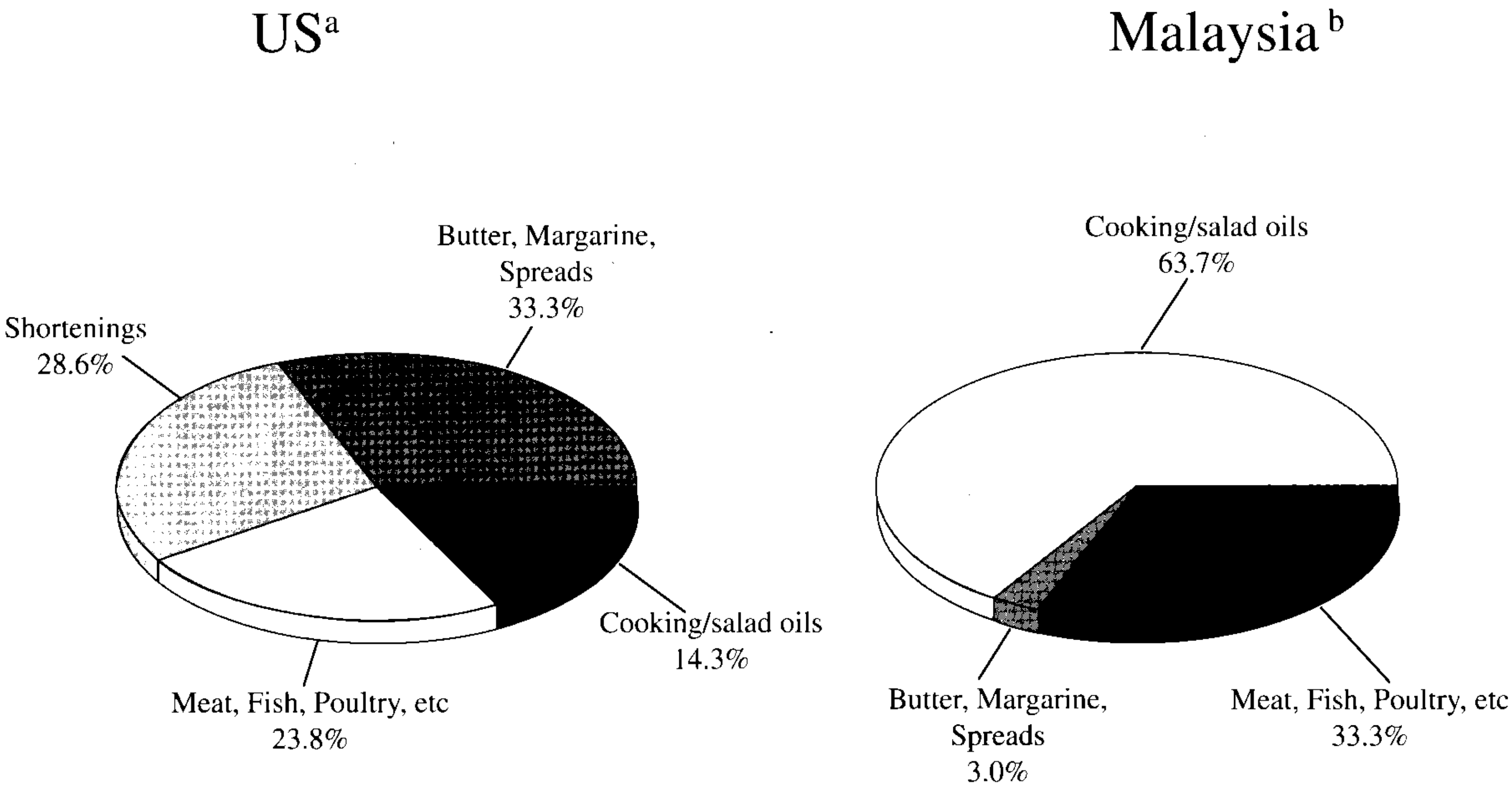
Studies in the US by Apgar *et al.*, (1987) with cocoa butter (melting point 30°C-35°C) indicated that it was 91% digestible in humans when ingested in amounts of up to 50g daily. Digestion of stearic acid was greater when ingested as a mixed glyceride than as tristearin. Since then, these observations have been extended by Rhee *et al.*, (1997).

Absorption of products of fat digestion

Short and medium chain fatty acids which have been released from dietary triglycerides by the pancreatic lipase in the intestinal lumen, do not take part in the resynthesis of triglycerides in the intestinal mucosal cell. These fatty acids leave the mucosal cells in the free form, enter the blood of the portal vein where they are bound to serum albumin and reach the liver.

Triacylglycerol hydrolysis is obligatory prior to absorption. However, this hydrolysis is not always complete. Free fatty acids and monoacylglycerols pass through the intestinal membranes and are re-esterified to triacylglycerols. Saturated fatty acids of carbon chain 18 are well absorbed in the Sn- 2 state (Perkins, 1983). There is so much excess capacity in healthy human gut to digest fat and solubilize the digested products that such compositional differences in fats are probably rarely of physiological significance. Palm stearin has only 5%-7% stearic acid and even if it were to constitute the major dietary fat in one's diet, there will not be any problems related to digestibility and absorption in normal individuals. This is because, palmitic acid rather than stearic acid is its major constituent fatty acid. The digestion and absorption of palmitic and oleic acids are well established. These are the two major constituent fatty acids in palm stearin.

Bonanome and Grundy (1989) examined the fatty acid composition of the chylomicron lipids in ten volunteers following administration of a fatty meal in which stearic acid was one of the components.



Fat content of diet = 160g/day (42% of Calories)

Fat content of diet = 66g/day (26% of Calories)

[a] Source : JF Mead, Lipids. Plenum Press, Ny. 1985.

[b] Source : TKW Ng, Mal J Nutr, 1 : 21-30, 1995.

Figure 6. Distribution (%) of Fats in the Diets

The amount of stearic acid in two sets of meals was 28.6% and 13.3% of the fat intake which was 85g and 65g respectively. They found that the percent of stearic acid in chylomicron lipids was similar to that of the dietary fat. If the absorption of stearic acid had been less than that of other dietary fatty acids, the percent of stearic acid in the chylomicron lipids should have been reduced. Since this did not occur, they concluded that stearic acid is absorbed approximately as well as other fatty acids including palmitic and oleic.

Background to the concern over digestibility of fats?

The digestibility of fats became a concern during the first World War (1914-1918) because of shortage of edible fats and the need to consume unorthodox fats. The United States Department of Agriculture tested many oils and fats (Langeworthy, 1923). It is worth noting that some fats had melting points above the body temperature *(Table 4)*.

TABLE 4. MELTING POINT AND DIGESTIBILITY OF FATS

Fat	Melting point (°C)	Digestibility (%)
Mutton	50	88
Deer fat	54	82
Hydrogenated Corn oil	50	89
Hydrogenated peanut oil	52	79
Hydrogenated cotton seed oil	50	87

Melting point of fats

The melting point is taken as the temperature at which all the fat becomes liquid. The melting point of triglycerides depends upon its fatty acid composition and the distribution of the fatty acids. The melting point of a fatty acid depends upon its chain length, degree of unsaturation and spatial configuration.

The digestibility of a fat is determined by:

$$\text{Digestibility} = \frac{\text{Fat ingested} - (\text{Fat excreted} - \text{obligatory fat})}{\text{Fat ingested}} \times 100$$

As for fats with melting point up to 50°C there was no significant reduction in digestibility. Digestibility related to the stearic acid content of the fat and the relationship with melting point was secondary. No doubt, digestibility was reduced with natural fats: beef, mutton and deer fats of high melting points. Only those fats hydrogenated to a melting point in excess of 50°C showed reduced digestibility and absorption trends. Partially hydrogenated fats are usually well absorbed. Overall their digestibility coefficient ranges from 79%-98% depending on the melting point.

Natural fats and oils are mixtures of triacylglycerols with as few as 20 in vegetable oils to as many as 200 in butter fat. The constituent glycerides will have different melting points ranging from -50°C to +60°C and the melting point of a particular fat is influenced by its composition as well as its association with other nutrients co-occurring in the digestive tract.

The melting point of a substance is a criterion of purity for a chemist and as such pure substances have definite melting points. Humans do not consume pure fatty acids or for that matter specific pure nutrients. They consume foods which contain a mixture of various nutrients. As such, there is no justification on nutritional grounds for a general melting point limitation for fats, without specifying its composition, intake and associated nutrients.

Berger (1979) has argued that since natural fats do not have a sharp melting point, but melt over a temperature range, it is not reasonable to continue to use melting point as a parameter in fat utilisation studies.

3. Perception:

Palm stearin may obstruct blood vessels and cause coronary heart disease because of its melting point being higher than normal body temperature.

Fact:

The physiological effects of fat occur after absorption. Fats are not absorbed as such, but only after hydrolysis. In the circulation they are present in the form of soluble lipoproteins. The usual edible fats are non-toxic. Palm stearin is non-toxic and is metabolised just like any saturated fat and can fulfill all the functions of fats. It is worth reiterating that the characteristics of the total diet rather than individual foods are of critical importance. Further, nutritional factors are not the sole cause of cardiovascular disease. There are many risk factors for ischaemic heart disease; some determined by the subjects' life style, but some of them are genetic. In many cases, genetic and nutritional factors go hand in hand to explain certain disorders. The earlier references provide adequate evidence to this fact (Perkins, 1983; Nelson, 1990).

4. Perception:

Consumption of palm stearin raises blood cholesterol levels.

Fact:

This is not true.

All saturated fatty acids are not equivalent in their cholesterolemic effects. This is especially so for those with less than 12 carbon atoms. In recent times, palmitic acid, another long chain saturated fatty acid has been shown to be neutral in its cholesterolemic effect (Hayes *et al.*, 1992; Khosla and Sundram, 1996). Several lines of evidence suggest that stearic acid does not raise serum cholesterol levels but on the contrary has been shown to have an hypocholesterolemic effect (Keys *et al.*, 1957).

Evidence:

The significant studies include those of Keys (1965) himself who showed that stearic acid has little or no effect on serum cholesterol levels in man. Bonanome and Grundy (1988) reported that consumption of a high stearic acid diet (2700 Calories) resulted in a decrease in plasma total and LDL cholesterol by 14%. In this study, 40% of the calories was provided by fats of which 42.9% (51.48g) was stearic acid.

5. Perception

Palm stearin is not used in food formulations and products.

Fact:

This is not correct.

Palm stearin is one of the preferred natural and cost effective components used by many manufacturers in formulations of consistent fats like margarines, shortenings, bakery fats, frying fats and vanaspati. In fact, food manufacturers worldwide have developed competence to maximise the use palm stearin to its technical limit in their food formulations *(Figure 5).*

The fact that palm stearin is used in non-food applications in some countries must not negate its usefulness as a food ingredient. An interesting analogy is between palm stearin and soyabean oil. Although soap manufacturers prefer palm stearin over the traditional tallow for techno-economic factors and soya oil is widely used in paint manufacture, both oils play important roles in the food industry and in meeting the global edible oils and fats demands.

TABLE 5. SOME PRODUCTS USING PALM STEARIN

Food	Non food
Shortenings	soaps
Vanaspati	Oleochemicals
Margarines	
Frying fats	
Speciality fats	
Dough fat	
Cookies/Biscuits	
Cake mixes	
Instant noodles	

6. Perception

The incorporation of palm stearin in food products does not provide a positive health image for the products.

Fact:

This is a wrong notion, not based on nutritional or health grounds, but more on misinformation, prejudices and old concepts. Palm stearin, the solid fraction of palm oil readily replaces tallow (whose supply is stagnant) and hydrogenated fats in shortenings, frying fats and other solid fat formulations. Palm stearin could be the cheapest and natural source of solid fats constituted mainly by palmitic, oleic and stearic acid packaged as high melting triglycerides. It has the added advantage of being cholesterol free and is used to replace animal fats such as lard and tallow whose use is not acceptable in certain cultures and countries *(Table 6).*

The world consumption of oils and fats can be classified into two equally important categories, *i.e.* 50% solid fats and 50% liquid oil markets. Under current pattern of consumer demand, there is a shortage in the supply of solid fats and oversupply in the liquid oils market. Palm oil and palm stearin is naturally placed in an advantageous position with respect to the pattern of large consumer demand for solid fats (Yusof, 1996).

Hydrogenated fats

Hydrogenation of liquid vegetable oils increases their melting point, plasticity, firmness and stability, thereby making them suitable ingredients for use in margarine, shortening and bakery fat formulations. However, the hydrogenation of vegetable oils results in the reduction of the levels of unsaturated fatty acids which are converted into isomeric (trans) fatty acids. Natural vegetable oils contain only the cis-isomers of fatty acids, but as a result of hydrogenation, a mixture of cis and trans isomers are produced (Karleskind, 1996).

Health concerns with trans fatty acids

The presence of fats containing trans fatty acids is of increasing concern to nutrition-

TABLE 6. PRICES AND PRODUCTION OF PALM STEARIN, TALLOW AND LARD

Fat/Oil	1986-95	1991-95	1996	1997
	Prices (US$/tonne)			
RBD palm stearin	373	408	496	461
Tallow	383	411	508	
Lard	525	514	598	
	1993	1994	1995	
	Production (x 1000 tonnes)			
RBD Palm stearin	786*	809*		
Tallow	7252	7416	7639	
Lard	5593	5682	5807	

Source: Oil World, 1997
*exports (PORLA, 1997)

ists as trans fatty acids are recognised as potential contributors to health risks (Willet and Ascherio, 1994). Studies show that trans fatty acids produced during the hydrogenation of highly unsaturated liquid oils not only raise the level of total serum cholesterol, they also increase the level of serum LDL-C and decrease HDL-C levels. They have also been reported to raise the Lp(a) levels, an independent risk factor for coronary heart disease. This recognition has led to reformulation efforts by food manufacturers who try to reduce the amount of trans fatty acid isomers in their products. The use of palm oil and its products has been found to obviate the need for extensive hydrogenation while reducing the formation of isomeric fatty acids. Considerable savings can be effected, as the cost factor involved to produce hydrogen by electrolysis as well as the use of metal catalysts are minimised. Interesterification of palm oil and palm oil products has also been succesfully adopted as a process to provide the solid fat content, thus eliminating the need for hydrogenated fats (Yusof *et al.,* 1998). Recent evidence also suggests that the use of palm oil products to replace hydrogenated oils and fats results in a more favourable human lipoprotein profile that reduces the risk for coronary heart disease (Sundram *et al.,* 1997).

Economising the hydrogenation process

Hydrogenation of liquid oils is expensive, because hydrogen is produced by electrolysis which involves high energy costs as well as the use of catalysts. The naturally solid consistency of palm stearin favours its use in the manufacture of margarines as it reduces hydrogenation costs. It is currently almost impossible to manufacture industrial margarines and a frying fat at low cost without incorporating palm oil/palm stearin. This is the present "health driven" trend in Europe and Asia (Yusof, 1996, Voituriez, 1996), which takes into account the adverse health concerns associated with the trans fatty acids.

CONCLUSION

The case for palm stearin as an useful palm oil product to meet the requirements for fat is well supported with scientific and economic evidence. This paper serves to break down the simplistic thinking in some quarters that fats are a health hazard and emphasises the need to distinguish the many features of a fat. It also helps to clear the many misconceptions which have been perpetuated on palm stearin. The misconceptions of a fat without regard to is wholesome characteristics seems grossly inappropriate. Nevertheless, there is no denying that there are no controversies on dietary fats and health and that there may be factors which are yet to be identified and more investigations required in this direction.

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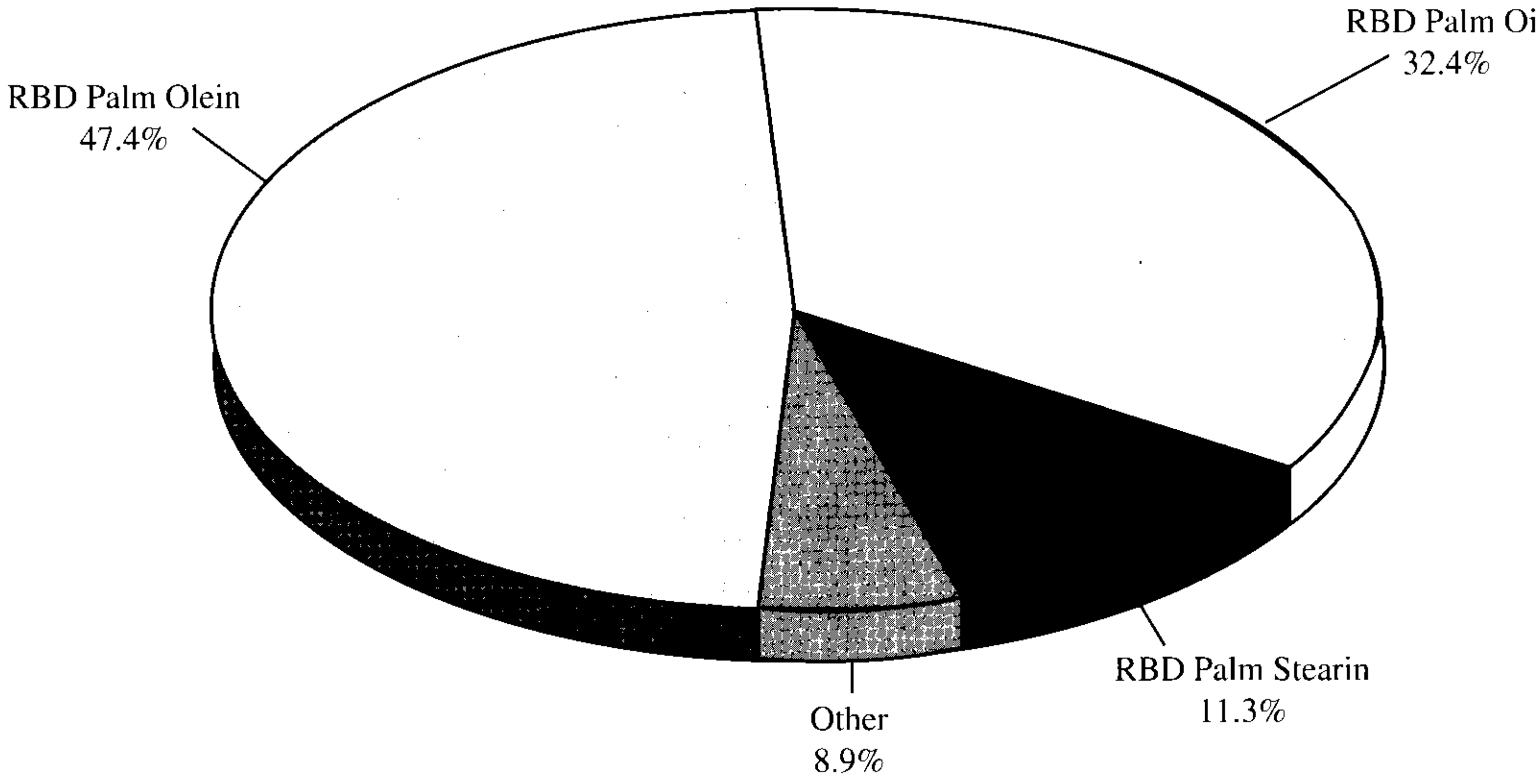

Figure 2. Export of Processed Palm Oil (1996) Total = 7 142 910 tonnes from Malaysia

Source: PORLA: Review of the Malaysian Palm Oil Industry (1996) trary. This paper endeavours to provide an overview of palm stearin, one of the products of palm oil with the aim of clarifying lingering perceptions, some based on misinformation and some, at times, factually incorrect. It also addresses some of the issues often raised by consumers.

What is palm stearin?

The term stearin is used for solid fractions of many oils and fats. This include beef tallow stearin, cocoa butter stearin, palm kernel stearin and palm stearin. Palm stearin is the solid fraction obtained from palm oil through the process of fractionation which involves cooling palm oil under controlled conditions to form fat crystals and separating the crystals (palm stearin) from the liquid phase (palm olein) using filtration techniques *(Figure 3)*.

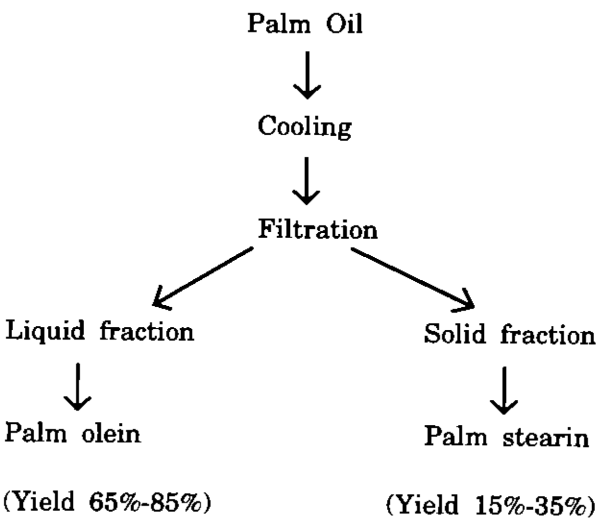

Figure 3. Processing of palm oil

Fractionation of palm oil

In palm oil fractionation, palm olein is the premium product and palm stearin is the discounted product. By varying the fractionation conditions, the relative yields of the two fractions can be changed. Fractionation can be modified to give products of different characteristics, notably palm mid fractions. The key characteristics of the starting oil and its fractions are listed in *Table 1*.

By fractionation, various grades of olein and stearin are available commercially, enabling the food manufacturers to select the properties they particularly require. The physical and chemical characteristics of stearin differ significantly from those of palm oil and palm olein and it is available in a wide range of fatty acid and triglyceride composition.

Palm oil products

By varying the cooling conditions and separation methods a range of palm stearins with different chemical and physical properties can be produced. When required fractionation conditions can be specifically altered to produce stearins of a desired specification for specialised applications (PORIM, 1994; Pantzaris, 1994). Red palm oil which retains more than 70% of the original carotene content is now available commercially. This too can be fractionated into red palm olein and red palm stearin. The red palm stearin can similarly be used in several food formulations, but with the added advantage of a higher content of the carotenoids and palm vitamin E compared to RBD palm stearin *(Figure 4)*.

It is evident from *Table 1* that palm oil and the resultant products from the fractionation process, namely palm stearin and palm olein, offer users of oils and fats all over the world greater choice and flexibility in tailoring the appropriate oil and fractions to suit their requirements. This is what we call the palm oil advantage, which is evident from the fact that palm oil products as a whole rank high in acceptability amongst the oils and fats used in the food industry worldwide.

1. Perception:

The major fatty acid component of palm stearin is stearic acid and it is therefore unsuitable for human consumption.

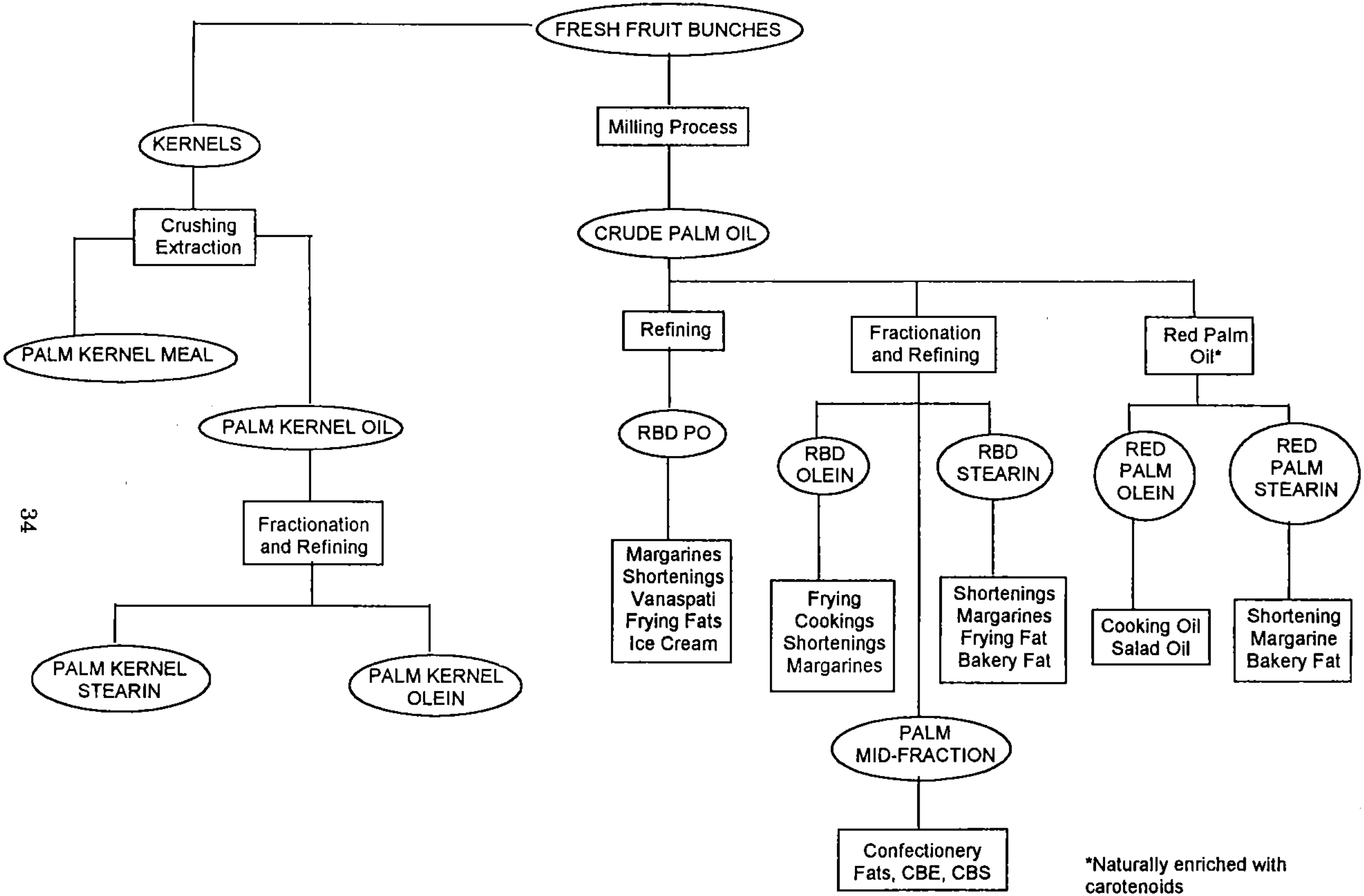

Figure 4. Palm Oil and Palm Kernel Oil Processing and Utilization

TABLE 1. FATTY ACID COMPOSITION OF PALM OIL PRODUCTS

	Palm Oil Mean	Palm Olein Mean	High IV Palm Olein Mean	Palm Stearin Typical	Palm Stearin Range	Cholesterolemic Effect
C14:0	1.1	1	1.1	1.3	1.1-1.9	↑
C16:0	44	39.8	31.5	54	47.2-73.8	*
C18:0	4.5	4.4	3.2	4.7	4.4-5.6	↓
C18:1	39.2	42.5	49.2	32.3	15.6-37.0	↓
C18:2	10.1	11.2	13.7	7	3.2-9.8	↓
C18:3	0.4	0.4	0.3	0.1	0.1-0.6	↓
Iodine Value	53	58	66.4	39.9	21.6-49.4	
Melting Point °C	36	21.6	12	51.3	44.5-56.2	
Cloud Point °C	–	8.8	2.2	–	–	

* Neutral under defined conditions (Ref. K.C. Hayes, (1992). FASEB J. 6: 2600-2607.

Fact:

This is incorrect.

The major fatty acid content of palm stearin is palmitic acid. Palm stearins's content of stearic acid is very low. In fact stearic acid constitutes only 4.4% - 5.6% of the total fatty acids in palm stearin *(Figure 5)*.

Stearic acid is present in many oils, fats and foods *(Table 2, 3)*. In the United States, the daily intake of stearic acid ranges from 10g-20g (Vergroesen, 1989). Palm stearin is a fully edible fat which has been accorded the GRAS status by Codex Alimentarius (1981). As a result, palm stearin can readily fulfill many of the physiological functions normally ascribed to oils and fats.

2. Perception:

Palm stearin is digested and absorbed with difficulty because of its melting point being higher than normal body temperature.

Fact:

This is not true. It is useful to outline the digestion and absorption of lipids and relate some authoritative studies on fat digestion and absorption.

Digestion of fats

Dietary fat is derived from several sources and most of the fat is ingested in the form of triglycerides *(Figure 6)*.

It is generally accepted that the chemical structure of a fat has a considerable influence upon its subsequent biological availability. In particular, chain length, degree of saturation, position of fatty acids on the triglyceride molecule and the proportions of free fatty acids, are all important determinants of subsequent digestibility and absorption and therefore of dietary energy value.

Digestion begins in the mouth, where chewing releases fat from other food components and the lingual lipase begins hy-