3 Fats

3.1 Introduction

Dietary fats perform important functions in our body. They provide the essential fatty acids [linoleic acid (LA) and alpha (α)-linolenic acid (ALA)] which are required for the synthesis of "local hormones" called eicosanoids which regulate metabolism. Fats provide the fatty acids (FA) which form structural components of biological membranes. This macronutrient allow "piggy-rides" for the fat-soluble vitamins (A, D, E and K) during absorption and distribution to body tissues. In addition, fats impart taste and texture to foods.

Fat is the major determinant of the energy density of diets, providing a high 9.0 kcal/g compared with the much lower 4.0 kcal/g for carbohydrate and protein. As such, people who consume high-fat diets (>35% energy) coupled with a sedentary lifestyle, would likely put on weight as they take in more calories than what they actually need.

3.2 Deficiencies

Fat deficiency is rare and usually occurs in individuals with malabsorption problems. When this happens, the availability of the essential fatty acids (linoleic acid and a-linolenic acid) and that of the fat-soluble vitamins (A, D, E and K) would be adversely affected. Clinical symptoms of fat deficiency include marked weight loss, dryness of the skin, and atopic eczema.

3.3 Food sources

Both separated fats (eg. cooking oils, margarines, butter, shortenings, etc.) and unseparated fats (fats in the tissues of food) contribute to the total fat in our diet. In Malaysia, vegetable cooking oils form the main source of fat in habitual diets, contributing as much as one-half to two-thirds (13%-18% kcal) of the total fat which approximates 60-70 g.

Unseparated fats from rice, vegetables and fruits, pulses and nuts, wheat products, and santan form another 4% kcal (10g), while the remaining 6% kcal (15g) or so are contributed by animal fats from eggs, chicken, beef, other meats, fish, anchovies, squid, etc. (Ng, 1995, 1997).

Palm olein and its popular blends form the bulk of the cooking oils available at local retail outlets and supermarkets. As such, palm oil is the major fat in the diet of Malaysians. Food Balance Sheets for Malaysia indicate that the per capita palm oil consumption approximates 17g/head/day which is probably the highest for the oil in the world.

3.4 Factors affecting requirements

The results of food consumption studies conducted in Malaysia over the last two decades indicate that average fat intakes vary appreciably amongst different population groups; for example, from 11% energy in rural villages in Sabah to 26% energy amongst urban adults in Kuala Lumpur (Ng, 1997). This is not surprising as food intake is influenced by several factors, two of the most important being socio-economic status and cultural preferences.

Physiological condition(s) [eg. pregnancy, lactation] and risk of certain chronic diseases such as heart disease and diabetes also affect fat requirements. This shall be discussed later especially with regard to the requirements for the polyunsaturated LA. As implicated earlier, cutting fat consumption would also reduce total calorie intake which would be beneficial for individuals with excess body weight problems.

3.5 Setting requirements and recommended intakes for fats

Dietary fat levels

The Malaysian Dietary Guidelines (NCCFN, 1999) has recommended a desirable fat intake range of 20%-30% energy, which is adopted by the Technical Sub-Committee (TSC) on Energy and Macronutrients in establishing recommended fat intakes. These dietary fat levels are within the range of 15-30% energy recommended by several WHO/FAO Expert Consultations over the years.

Fat is an essential nutrient and its dietary level should not fall too low, otherwise the diet prepared becomes monotonous, has low palatability, low energy density, and the amount of EFA or LA can become limiting. The minimum dietary fat level is set as 15% energy by WHO (1990) and WHO/FAO (2003). The TSC felt that this lower limit is not within the "desirable" range.

At the high end, the TSC notes that the FAO/WHO (1994) and WHO/FAO (2003) reports consider a relatively high fat intake of 35% kcal as acceptable if one is active, which incidently is also the upper level recommended for the macronutrient by the DRI Committee of IOM (2002). However, the introduction of the 35% energy fat as acceptable in the 1994 FAO/WHO Report may cause some confusion in the Malaysian context and therefore was not adopted by the TSC on Energy and Macronutrients.

The fat intake recommendations by the TSC on Energy and Macronutrients are given in bold in the following paragraphs according to age groups and summarised in Appendix 3.1. The table also summarises the recommended intake for the fatty acid components.

Infants

Whenever possible, breast milk is the preferred source of nutrition for infants in this age group. Human milk provides 50-60% of its energy as lipid in which about 5% energy is EFA (LA + ALA) with 1% energy as long-chain polyunsatyrated fatty acids (LCPUFA). During lactation in well-nourished mothers, milk fat contribution increase from 40-50 g/litre at three weeks to 60-70 g/litre at 4-6 months (FAO/WHO, 1994).

The absolute amounts of dietary fat recommended per day by the TSC on Energy and Macronutrients for this age group are calculated based on the current proposed Malaysian RNI for energy of 560 kcal with 50-60% contributed by fat calories.

During weaning, the fat component should provide 30-40% of the dietary energy (FAO/WHO, 1994). This means that complementary foods used during the weaning period should include adequate amounts of fats and oils as the breastmilk component of the diet declines.

The absolute amounts of dietary fat recommended per day by the TSC on Energy and Macronutrients are calculated based on the current proposed Malaysian RNI for energy of 640 kcal with 30-40% as fat calories.

RNI for infants

0 - 5 months	**31 - 37 g/day**
6 - 11 months	**21 - 28 g/day**

Children, adolescents, adults and elderly

The amount of fat for these age groups are calculated from the current proposed energy requirements for Malaysians with 20-30% as fat calories. For the group 1-3 years, however, a higher fat intake range of 25-35% kcal was adopted to allow for the "transition period" from infancy where the amount of calories from fat is higher (30-40% kcal).

RNI for children

Boys	**1 – 3 years**	**27 - 38 g/day**
	4 – 6 years	**30 - 45 g/day**
	7 – 9 years	**40 - 59 g/day**
Girls	**1 – 3 years**	**25 - 35 g/day**
	4 – 6 years	**29 - 43 g/day**
	7 – 9 years	**35 - 53 g/day**

For adolescent boys and girls (10-18 years), 20-30% of the unweighted means for daily energy requirements of 2570 kcal and 2073 kcal respectively, were used to calculate the absolute amounts in grams of fat required per day.

RNI for adolescents

Boys	**10 – 18 years**	**57 - 86 g/day**
Girls	**10 – 18 years**	**46 - 69 g/day**

Similarly for adults 19 to 59 years of age, 20-30% of the unweighted means for daily energy requirements of 2450 kcal for men and 2090 kcal for women were used to calculate the recommended daily amounts of dietary fat. For the elderly, the recommended fat intake was computed based on energy requirements of 2010 kcal for men and 1780 kcal for women.

RNI for adults

Men	**19 - 59 years**	**54 - 82 g/day**
Women	**19 - 59 years**	**46 - 70 g/day**

RNI for elderly

Men	**≥ 60 years**	**45 - 67 g/day**
Women	**≥ 60 years**	**40 - 59 g/day**

Pregnancy

During pregnancy, there is an additional requirement for dietary fat to provide for maternal fat storage during the early trimester, and subsequent uterine growth, preparative development of the mammary glands, the expansion of blood volume, and placental and foetal growth in the second and third trimesters (FAO/WHO, 1994). Although the recommended range of dietary fat remains at 20-30% energy during pregnancy, the increased dietary fat needs are reflected in the higher daily energy requirements currently proposed for the second (+360 kcal) and third (+470 kcal) trimesters (see Chapter 2 on Energy). Similarly, the increased dietary fat needs correspond to the proposed addition of 500 kcal per day for lactation during the first six months.

RNI for

Pregnancy, 2nd trimester	**54 - 82 g/day**
Pregnancy, 3rd trimester	**57 - 85 g/day**
Lactation, 1st 6 months	**58 - 86 g/day**

Intake of linoleic acid (LA)

The essential fatty acids, LA (18:2, omega-6) and ALA (18:3, omega-3), must be provided by dietary fats because animals and humans cannot synthesise these FA nor introduce carbon-carbon double bonds at the omega-6 and omega-3 positions of the FA molecule. However, these two EFA can undergo chain-elongation to produce long-chain PUFA derivatives of 20 carbons [eg. arachidonic acid and eicosapentaenoic acid (EPA)] and 22 carbons [eg. docosahexaenoic acid (DHA)] chain length, resulting in two families of omega-6 and omega-3 FA. The minimum requirement for EFA in humans to prevent biochemical and clinical evidence of EFA deficiency is 1-2% energy. For infants and adults, a dietary intake of at least 3% energy of LA is considered adequate (FAO/WHO, 1977).

During pregnancy, the additional demand for uterine, placental and foetal growth, together with the increased maternal blood volume and mammary gland development, raises the EFA requirement by 1.5% energy in the maternal diet, adding up to a total of at least 4.5% energy EFA (FAO/WHO, 1977).

During lactation, it has been estimated that about 3-5g of EFA are secreted in the average of 850 ml milk produced per day; part of this amount will be as long chain-PUFA. All things considered, the EFA requirements during lactation is recommended at 2-4% energy above basic EFA requirements, making the total requirement as 5-7% energy (FAO/WHO, 1977). This physiological condition during lactation probably represents human's highest requirement for dietary LA.

Over the years, however, there has been much emphasis to increase dietary LA levels to counter the cholesterol-raising effects of the carbon 12-16 SFA (lauric, myristic, and palmitic acids). This concern for SFA has prompted the 1993 FAO/WHO Expert Consultation on Fats and Oils in Human Nutrition to recommend high LA intakes of 4-10% energy (FAO/WHO, 1994).

Subsequently in 2003, the FAO/WHO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases also recommended comparatively high 5-8% kcal LA and 1-2% kcal omega-3 fatty acids, which means a total of 6-10% dietary PUFA. The IOM has recommended LA intakes of 5-10% energy.

In the Malaysian context, the above recommendations for LA intake are very high and seemingly, could only be achieved if polyunsaturated vegetable oils form the major source of fat in the local diet. As such, this report recommends dietary LA levels of 3-7% kcal as adequate for the general Malaysian population, which coincides with the range of LA intake recommended in the Malaysian Dietary Guidelines (NCCFN, 1999). This range of LA intake proposed would also harmonise with the EFA intakes recommended by FAO/WHO (1977).

For individuals who are hypercholesterolemic, LA intakes in the range of 5 to 7% kcal coupled to a prudent diet low in fat (20-25% kcal) and cholesterol (<300 mg.day) but rich in vegetables and fruits, (and therefore fibre, particularly soluble fibre) are considered sufficient to help lower plasma cholesterol levels by 10-15% over a period of 1 to 3 months.

Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and trans fatty acids (TFA)

The C12-16 SFA (lauric, myristic, and palmitic acid) do not have the same cholesterol-raising potential. Mystistic acid has at least 4 times the cholesterol-raising potential of palmitic acid (Hegsted *et al*., 1965). Of interest, much evidence has accumulated to show that palm-based diets, which are high in palmitic and oleic acids, tend to be non-cholesterol raising when consumed by different populations across the globe (Hayes *et al*., 1991; Ng *et al*., 1991 & 1992). WHO/FAO (2003) has reiterated that as a population nutrient intake goal, total SFA should be <10% kcal and the TSC on Energy and Macronutrients concurs with this moderate stand.

It is important to note that although SFA raise total cholesterol (TC) and LDL-cholesterol, they also raise plasma levels of the protective HDL which then "buffers" any serious rise in the LDL/HDL ratio as a result of increased intakes of fats rich in SFA. Also, the LDL/HDL ratio may not necessarily improve when dietary SFA levels go too low (eg. <7% kcal) as happens during high LA intakes; otherwise, the plasma LDL particles generated are smaller and more dense, and therefore, more atherogenic (Hayes, 2002).

It has been observed that gram-for-gram the trans fatty acids (TFA) contained in commercially hydrogenated fats are associated with a considerably (2.5-fold to >10-fold) higher risk increment for heart disease (Ascherio *et al*., 1999; Stender & Dyerberg, 2004). Recognising these effects, the WHO/FAO (2003) has recommended an upper intake limit of 1% kcal of the diet for TFA.

Monounsaturated FA (MUFA) are largely "neutral" and it would be prudent to maximise their level in the diet as they tend to displace the harmful FA. However, extremes of MUFA intake (approx. >15% kcal) should be avoided as oleic acid (the most abundant dietary MUFA) has been reported to increase the haemostatic risk factors, fibrinogen and factor VIIc activity (Sanders, 1996)

Omega-6/omega-3 fatty acid balance

The omega-6 FA in the diet consists of mainly LA and its metabolite, arachidonic acid (AA), while the omega-3 FA comprises ALA, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Currently, the omega-6/omega-3 FA ratio of the typical

Malaysian diet is about 3.5/0.35, i.e. 10 (Ng, 1995), while in the diets of western populations this ratio is much higher, i.e. 15-20. FAO/WHO (1994) recommends an omega-6/omega-3 FA ratio of 5-10.

Both the absolute amounts of omega-6 and omega-3 FA, as well as their ratio are important nutritional considerations. Increasing the intake of omega-3 poses a serious challenge and any excess intake of LA (>7% energy) would make achieving the recommended omega-6/omega-3 FA ratio even more difficult.

In the Malaysian context, omega-6 PUFA (LA) intakes are recommended at 3 to 7% kcal, while omega-3 PUFA at 0.3 to 1.2% kcal. This range of omega-3 FA intakes is recommended with due consideration to the present omega-3 content of habitual Malaysian diets and the practicability of increasing the intake which requires substantial changes in dietary habits.

The omega-3 fatty acid intake of the average Malaysian is currently low and there are at least three ways that we can remedy this, namely: (1) eat more pulses (eg. beans, dhall), taufu and fish, (2) use a cooking oil that is a blend of palm olein + an omega-3 rich vegetable oil (eg. canola, soybean), and (3) include omega-3 (ALA or EPA + DHA) rich novel foods in the household food basket.

Foods which serve as good sources of omega-3 fatty acids include the following:

Flaxseed oil, perilla oil (50-60% ALA)
Canola oil, rapeseed oil (11% ALA)
Soybean oil (8% ALA),
Fish (especially deep-sea type), other seafoods (EPA + DHA)
Omega-3 enriched eggs (EPA + DHA)
Fish oi1- eg. cod liver oil (EPA + DHA)
Pulses (eg. beans, dhall), certain nuts/seeds (eg. walnut, linseed)

Discussions on revised RNI for Malaysia

The recommended intake for fat and its components for Malaysia are compared with that of the WHO/FAO (2003) and the IOM (2002) in Appendix 3.1.

Values quoted for WHO/FAO in the above table are based on the 2003 WHO Expert Consultation on *Diet, Nutrition and the Prevention of Chronic Diseases* which recommends slightly lower values for LA (5.0-8.0% energy) and total fat (30% energy) compared with the 1993 FAO/WHO Expert Consultation of Fats and Oils in Human Nutrition (4.0-10.0% energy LA and 35% energy total fat).

The lower range of 3.0 to 7.0% energy LA currently recommended for Malaysia have been made based on two main considerations, namely (i) harmonization with values recommended for LA as the predominant essential fatty acid, and (ii) practicability of achieving the LA levels recommended based on the typical Malaysian diet.

In the table (Appendix 3.1), total fat values recommended for Malaysian infants are adopted from WHO/FAO (1993, 2003), which incidently also agree with the values cited by IOM (2002). For older Malaysian subjects, however, the rationale for recommending the dietary fat levels shown in the table have been discussed earlier under the section "Dietary fat levels".

3.7 References

Ascherio A, Katan MB, Stampfer MJ & Willett WC (1999). Trans fatty acids and coronary heart disease. *N Engl J Med* 340(25):1994-1998.

FAO/WHO (1977). *Dietary Fats and Oils in Human Nutrition.* A Joint FAO/WHO Report, Food and Nutrition Paper No. 3. Food and Agricultural Organisation, Rome.

FAO/WHO (1994). *Fats and Oils in Human Nutrition*. Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Paper 57. Food and Agriculture Organization, Rome.

Hayes KC (2002). Dietary fat and heart health: in search of the ideal fat. Asia Pacific *J Clin Nutr* 11:S394-S400.

Hayes KC, Pronczuk A, Lindsey S & Diersen-Schade D (1991). Dietary saturated fatty acids (12:0, 14:0, 16:0) differ in their impact on plasma cholesterol and lipoproteins in nonhuman primates. *Am J Clin Nutr* 53:491-498.

Hegsted DM, McGandy RB, Myers ML & Stare MJ (1965). Quantitative effects of dietary fat on serum cholesterol in man. *J Clin Nutr* 17: 281-295.

IOM (2002). *Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients).* National Academy Press, Washington D.C.

NCCFN (1999). *Malaysian Dietary Guidelines*. National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Kuala Lumpur.

Ng TKW, Khalid H, Lim JB, Lye MS & Ishak R (1991). Nonhypercholesterolemic effects of a palm-oil diet in Malaysian volunteers. *Am J Clin Nutr* 53:1015S-1020S.

Ng TKW, Hayes KC, De Witt GF, Jegathesan M, Satgunasingham N, Ong ASH and Tan DTS (1992). Dietary palmitic and oleic acids exert similar effects on serum cholesterol and lipoprotein profiles in normocholesterolemic men and women. *J Am Coll Nutr* 11(4):383-390.

Ng TKW (1995). Towards improved fat intake and nutrition for Malaysians. *Mal J Nutr* 1:21-30.

Ng TKW (1997). Dietary fat and fibre intakes of Malaysian adults: issues and implications when 'western targets' are set as dietary goals. *Mal J Nutr* 3:137-147.

Sanders TAB (1996). Dietary fat and thrombosis. In: *Proceedings of the PORIM International Palm Oil Congress*, 23-28 September 1996, Kuala Lumpur.

Stender S & Dyerberg J (2004). Influence of trans fatty acids on health. *Ann Nutr Metab* 48:61-66.

WHO (1990). *Diet, Nutrition and the Prevention of Chronic Diseases*. Report of a WHO Study Group. Technical Report Series 797. World Health Organisation, Geneva.

WHO/FAO (2003). *Diet, Nutrition and the Prevention of Chronic Diseases*. Report of a Joint WHO/FAO Expert Consultation. WHO Technical Report Series 916. World Health Organisation, Geneva.

Appendix 3.1 Comparison of recommended intake of fat and its components: RNI Malaysia (2005), WHO/FAO (2003) and IOM (2002)

Nutrient	Age groups	Malaysia (2005)		WHO/FAO (2003)	IOM (2002)
		Recommended intake (g/day)	% of total energy intake	% of total energy intake	
Total fat	Infants				
	0 - 5 months	31 - 37	50 - 60	50 - 60	50 - 60
	6 - 11 months	21 - 28	30 - 40	30 - 40	30 - 40
	Children (boys)				
	1 - 3 years	27 - 38	25 - 35	15 - 30	30 - 40
	4 - 6 years	30 - 45	20 - 30	15 - 30	25 - 35
	7 - 9 years	40 - 59	20 - 30	15 - 30	25 - 35
	Children (girls)				
	1 - 3 years	25 - 35	25 - 35	15 - 30	30 - 40
	4 - 6 years	29 - 43	20 - 30	15 - 30	25 - 35
	7 - 9 years	35 - 53	20 - 30	15 - 30	25 - 35
	Adolescents (10 - 18 years)				
	Boys	57 - 86	20 – 30	15 - 30	25 - 35
	Girls	46 - 69	20 - 30	15 - 30	25 - 35
	Adults (19 - 59 years)				
	Men	54 - 82	20 - 30	15 - 30	25 - 35
	Women	46 - 70	20 - 30	15 - 30	25 - 35
	Elderly (≥ 60 years)				
	Men	45 - 67	20 - 30	15 - 30	25 - 35
	Women	40 - 59	20 - 30	15 - 30	25 - 35
	Pregnancy				
	2nd trimester	54 - 82	20 - 30	15 - 30	25 - 35
	3rd trimester	57 - 85	20 - 30	15 - 30	25 - 35
	Lactation				
	1st 6 months	58 - 86	20 - 30	15 - 30	25 - 35
Omega-6 PUFA (linoleic acid)	General population	-	3.0 - 7.0	5.0 - 8.0	3.0 - 10.0
	Pregnancy	-	5.0 - 7.0	5.0 - 8.0	5.0 - 10.0
	Lactation	-	5.0 - 7.0	5.0 - 8.0	5.0 - 10.0
Omega-3 PUFA (ALA + EPA + DHA)	General population	-	0.3 - 1.2	1.0 - 2.0	0.6 - 1.2
Saturated fatty acids		-	< 10	< 10	< 10
Monounsaturated fatty acids		-	12 - 15	-	-
Trans fatty acids		-	< 1	< 1	-