糖尿病知識和行爲問卷 (DKB) 的評估

摘要

目前認定可能通過生活方式的轉變來I型（非胰島素依賴型）糖尿病進行預防。目前在實施對人群預防糖尿病的策略。新西兰南奥克兰市（South Auckland）糖尿病研究項目已研製了一份問卷來評估當地社會的糖尿病覺知、運動／健康飲食計劃的效果。問卷已用來評估當地成人包括歐洲（n = 127）、毛利（n = 103）和太平洋島民成人（n = 187）。問卷用以直接調查並約需30分鐘。糖尿病知識用4個選擇性問題和31個閉合／負面評估，這些問題在所有種族中都獲得良好的可靠性（Cronbachs α範圍 0.59－0.90）、重複性（Persons r範圍 0.39－0.74）和客觀的確實性（r範圍 0.28－0.56）。再測試時中間增加7－13%。在那些患有糖尿病或有糖尿病家族史的人中，問卷和問卷問題分數分別為 7－13%和10－26%。作者用四種方法來評估重要的飲食習慣：（1）七項食物製備／脂肪含量「脂肪指數」、（2）四項高脂／高精碳化合物、當飲食評估相比較（總脂肪 r = 0.44－0.90）、有良好可靠性（Cronbachs α範圍 0.51－0.74）、重複性（r = 0.37－0.70）和客觀的確實性（r = 0.45－0.52）、（3）12項食物頻率問卷亦具有良好重複性（Pearsone r = 0.45－0.64）和脂肪指數 r = 0.41－0.65）的飲食評估有著良好相關。就一個簡單的與水果進食頻率有關的問題與歐洲人（r = 0.25, p < 0.05）和毛利人（r = 0.33, p < 0.01）的脂肪指數有著相關。該問卷表現在對營養習慣進行質量評估，但它提供一個迅速的方法，去評估和指導II型（非胰島素依賴型）糖尿病的控制和預防。

Nutritional aspects of palm oil: an introductory review
Augustine S. H. Ong PhD
Malaysian Palm Oil Promotion Council, 1st Floor Bangunan Getah Asli, 148 Jalan Ampang, 50450 Kuala Lumpur, Malaysia.

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Introduction

Although palm oil has been consumed for 5000 years in Africa, where the palm tree originated, its significance as a dietary fat world-wide was not realized until 1984, when it became the largest selling edible oil in the export trade of oils and fats. By 1991 its share of the trade had risen to 33%. More than 90% of palm oil traded is used for food applications, where its versatility and stability are very advantageous. For example, in margarine and shortenings palm oil can stabilize beta prime crystals and this property will ensure a pleasant texture in these products.

As palm oil is mainly used in foodstuffs, interest in nutritional research on the oil naturally arose, and this was further stimulated and accelerated as a result of the anti-palm oil and anti-tropical oil campaigns. Several research groups all over the world have examined this problem and their findings have been published in respected international journals such as the American Journal of Clinical Nutrition and Nutrition Research. There has been a move towards using partially hydrogenated fat in place of palm oil, particularly in the USA. However, recent findings on hydrogenated fat indicate that the trans fatty acids which are formed during the partial hydrogenation of fats and oils may have adverse effects on the human blood lipid profile.

Because of the growing importance of palm oil in the human diet, and also because of the questions arising in regard to the use of hydrogenated fats as an alternative to it, it seemed useful and timely to prepare this summary of recent research findings on palm oil in relation to human nutrition. It differs in style and layout from a formal review, since the intention is to present the essential facts simply and succinctly. The excellent review by Elton provides further reading in greater detail.

The nutritional attributes of palm oil

Palm oil in the codex alimentarius

Palm oil is one of the 16 edible oils possessing an FAQ/WHO Food standard under the Codex Alimentarius Commission Programme.

The Codex Aliments Commission (Codex 125-1981) comprises 122 member countries. The primary purpose of the Commission programme is to protect the health of consumers and ensure fair practices in the food trade.
Table 1. Detailed fatty acid composition of palm oil, palm kernel oil, and coconut oil.

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>Palm Oil</th>
<th>Palm Olein</th>
<th>Palm Kernel Oil</th>
<th>Coconut Oil</th>
</tr>
</thead>
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</tr>
</tbody>
</table>

Number of samples 45 54 21

Table 2. Cholesterol content of crude oils and fats (references 65 and 66; cholesterol ppm). The data is representative of a typical Malaysian diet, with 35% of the energy content as fat. The palm olein rich diet did not significantly alter plasma total, HDL-C, or LDL-C concentrations. The concentrations of apolipoprotein A1 (+11%) and apolipoprotein B (-49%). The ratio of Apo A1 to Apo A1 was not significantly affected. It was concluded that there was no adverse effect on fat absorption.23 When another study, carried out in 33 subjects, used a Malaysian diet with 34% of the calorie intake as fat. When palm olein formed 74% of the total cholesterol concentration was significantly lower than the level at entry (-9%), and the level on a diet with coconut oil (-20%). LDL-C and HDL-C were also lowered, and the LDL/HDL cholesterol ratio was reduced.

Cholesterol is virtually absent from palm oil. The cholesterol content of all vegetable oils, including palm oil, is negligible. Before 1960 it was believed that vegetable oils contained no cholesterol at all, but with the advent of highly sensitive analytical methods such as gas chromatography, it was established that, alongside a mixture of plant steroids, predominantly B-sitosterol, trans fats amount of cholesterol were also detectable in plant oils.

Table 2 gives typical values for the cholesterol content of a number of crude edible vegetable oils in parts per million. As can be seen, these values are one or two orders lower than those for the cholesterol content in animal fats: they are nutritionally insignificant.

Palm oil and the avoidance of trans fatty acids

For many years palm oil did not require hydrogenation, thus avoiding the formation of the trans fatty acids and uncommon cis-fatty acids found in hydrogenated oils.34,35 Palm oil, as a semi-solid fat at 20°C, has natural physical properties which are needed in a number of important food applications. Many other vegetable oils must be partly hydrogenated to attain these properties, and this process generates a range of trans- and uncommon cis-fatty acids. Some of these isomers are recognized as having potentially negative effects on fatty acid metabolism and cellular function.36,37 Recent reports from independent research groups show that trans-fats raise plasma LDL cholesterol38-40 and lipoproteins41-43 in comparison with a diet containing predominantly cis unsaturated acids. (The significance of lipoprotein(a) is discussed later in this article.) In a recent epidemiology study involving almost 50,000 women linked trans fatty acid consumption with increased risk of coronary heart disease.

Tocopherols, tocotrienols, carotenoids

Refined palm oil, as used in food, is a rich source of vitamin E and related substances (tocopherols and tocotrienols, about 500 ppm). Unrefined palm oil is also a rich source of carotenoids.

Tocopherols and tocotrienols are natural antioxidants. Also, animal experiments have shown that tocotrienols inhibit the enzyme HMGCoA reductase and consequently the synthesis of cholesterol.

The tocopherols and tocotrienols act as scavengers of damaging oxygen-free radicals that have been suggested as playing a role in cellular ageing, atherosclerosis and cancer39,40. Laboratory experiments on isolated rat heart’s have shown that a tocopherol/ tocotrienol concentrate from palm oil is more efficient than alpha-tocopherol in protecting the heart against the oxidative injury usually associated with re-perfusion24.

When the same tocopherol/tocotrienol concentrate was used to treat patients with intermittent claudication in a controlled clinical trial, the test subjects showed a significant increase in walking distance before onset of pain, as compared with the groups given aspirin or a placebo. A measure of oxidation of their serum lipids was also significantly reduced24.

Low-density lipoproteins (LDLs) are involved in the formation of atherosclerotic lesions, which may be exacerbated when the unsaturated fatty acid content in LDL has become oxidized26. The antioxidants protect LDL from oxidation.

In a recent cross-cultural epidemiological study the amount of vitamin E in plasma showed a strong inverse correlation with age-specific mortality from coronary heart disease (CHD). The plasma levels of vitamin E appeared to be more important than total plasma cholesterol in explaining cultural differences in CHD mortality. Similar conclusions could not be drawn from studies within a population, however22. In a recent publication on lipid oxidation in skeletal muscle induced by exercise, the authors concluded that there was substantial protection against both resting- and exercise-induced protein oxidation by vitamin E in association with various isomers (alpha-tocopherol, alpha-tocotrienol) of vitamin E.

Unrefined palm oil is a traditional food in West Africa and parts of Brazil, although it is not widely available as a commercial product elsewhere. The main component of the palm kernel oils is B-carotene, which is a precursor of vitamin A.

The question of whether or not B-carotene has a protective role against some types of cancer is an active area of research.23,24

Digestibility of palm oil

Like other common edible fats and oils, palm oil is readily digested, absorbed and utilized as a source of energy.

Shortages of food fats during and after the First World War led to extensive research into the digestibility of fats, in order to justify the use of unconventional sources. This work has been reviewed in detail.42 It has been shown repeatedly that fats in general, including palm oil, have a digestibility of 97-99% unless their content of long-chain saturated fatty acids – stearic acid (18:0) and longer – is reduced. A reduction in digestibility only occurs when the melting point of the fat consumed exceeds 46-48°C.

Palm oil and serum cholesterol

Recent controlled human studies in Europe, the USA and Asia have confirmed that serum total cholesterol does not increase when palm oil is used to replace the major part of other fats in a traditional diet.20 This is in contrast to substitution with the more saturated coconut oil.

The amount of cholesterol in the blood is an indicator of risk for cardiovascular disease44,45, and numerous studies have investigated the influence of dietary lipids on blood cholesterol levels.46-48. Although there are still unresolved questions, it now seems probable that most prevalent polyunsaturated fatty acid (linoleic acid) has a cholesterol-lowering effect, while the saturated fatty acids of the fat, the saturated animal fats, consistently increase serum cholesterol levels of normo-cholesterolemic people.49,50

In hypercholesterolemic individuals with normal LDL receptor activity, palm oil is neutral.51,52 In hypercholesterolemic individuals with normal LDL receptor activity, palm oil is neutral.51,52

Early human studies indicated that palm oil can reduce the total serum cholesterol level in individuals with hypercholesterolemia53,54. The minimal effect was on normocholesterolemic individuals.54,55,56,57 Brief summaries of the more recent, controlled studies are given below:

(1) A double blind, crossover study was carried out in Holland on 38 men. In this trial 70% of the fat in a normal Dutch diet was replaced by palm oil. The following significant results were obtained.

- A decrease in serum total cholesterol
- An increase in HDL-C cholesterol
- An increase in apolipoprotein A1
- A decrease in apolipoprotein B
- A decrease in apolipoprotein A1 ratio
- A 20% decrease in LDL/HDL ratio

There was an association increase in serum apolipoprotein A1 and decreases in apolipoprotein B and the apoB/apoA1 ratio.

It was concluded that the changes effected by the palm oil rich diet might slightly reduce the cardiovascular risk profile.

(2) In the same project plasma lipoprotein(a) was also measured. There was a highly significant 10% decrease in Lp[a] (a) during consumption of the palm oil rich diet. This result was consistent with those from two other independent laboratories (see later in this article).

(3) In a study of 30 middle-aged men,16 six different fats were fed as ingredients in a normal American diet, forming 60% of the total fat intake. Fat represented 40% of the dietary energy. When palm oil was the test fat, total cholesterol was not affected but HDL-cholesterol (HDL-C) and apolipoprotein A1 increased, while apolipoprotein B decreased relative to baseline.

(4) Feeding nine men a diet containing 35% of the energy as fat, and one half of the fat as palm oil produced no change in plasma total or LDL-C, but a small rise in HDL-C occurred.

(5) Two trials were reported using 21 and 30 subjects, respectively, in which both the dietary fat intake was supplied as potato crisps fried in the test oil. When palm olein was used there was a small rise in plasma HDL-C, which accounted for a 3% rise in total cholesterol.

(6) The effect of palm olein, used as the cooking oil in the preparation of food for 110 high school students, has been reported.46 The study represented a typical Malaysian diet, with 35% of the energy content as fat. The palm olein rich diet did not significantly alter plasma total, HDL-C or LDL-C levels. Fat intake significantly increased the concentrations of apolipoprotein A1 (+11%) and apolipoprotein B (-49%). The ratio of Apo A1 to Apo A1 was not significantly affected. It was concluded that there was no adverse effect on fat absorption.23 When another study, carried out in 33 subjects, used a Malaysian diet with 34% of the calorie intake as fat. When palm olein formed 75% of the total cholesterol concentration was significantly lower than the level at entry (-9%), and the level on a diet with coconut oil (-20%). LDL-C and HDL-C were also lowered, and the LDL/HDL cholesterol ratio was reduced.

(7) A study has been reported on 83 subjects consuming a Malaysian diet with 30% of the calorie intake as fat. When palm olein formed 75% of the total cholesterol concentration was significantly lower than the level at entry (-9%), and the level on a diet with coconut oil (-20%). LDL-C and HDL-C were also lowered, and the LDL/HDL cholesterol ratio was reduced.

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The thromboxane/prostacyclin ratio in plasma was significantly reduced in the palm olein dietary period as compared with the olive oil period.

Palm oil and HDL-cholesterol

It is noteworthy that several of the studies summarized...
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<table>
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<th>Fatty acid</th>
<th>Palm oil</th>
<th>Palm olein</th>
<th>Palm kernel oil</th>
<th>Coconut oil</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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</tbody>
</table>

**Number of samples 45**

54 21

**Distinction between palm oil, palm olein, palm kernel oil and coconut oil**

Palm oil and palm olein must be distinguished clearly from palm kernel oil and coconut oil, because they have a very different fatty acid composition, with an appreciably lower level of saturated components, and no significant content of capric, lauric or myristic acids.

The oil palm is unique in producing two distinct edible oils from one fruit. Palm oil and its more liquid fraction, palm olein, is obtained from the flesh of this fruit, while palm kernel oil is obtained from its seed or kernel. The composition of palm kernel oil is similar to that of coconut oil, though it is slightly more unsaturated. The two oils are compared with palm oil and palm olein in Table 1. It will be seen that palm olein is quite different from coconut oil.

The figures given in this case are the average of determinations on samples from the main producing areas.

**Cholesterol is virtually absent from palm oil**

The cholesterol content of all vegetable oils, including palm oil, is negligible. Before 1960, it was believed that vegetable oils contained no cholesterol at all, but with the advent of highly sensitive analytical methods such as gas chromatography, it was established that, alongside a mixture of plant steroids, predominantly B-sitosterol and stigmasterol, about 500 ppm. Unrefined palm oil is also a rich source of carotenoids.

Tocopherols and tocotrienols are antioxidants. Also, animal experiments have shown that tocotrienols inhibit the enzyme HMG-CoA reductase and consequently the synthesis of cholesterol.

The tocopherols and tocotrienols act as scavengers of damaging oxygen-free radicals that have been suggested as playing a role in cellular ageing, atherosclerosis and carcinogenesis. Laboratory experiments on isolated rat heart muscles have shown that a tocopherol/ tocotrienol concentrate from palm oil is more efficient than alpha-tocopherol in protecting the heart against the oxidative injury usually associated with coronary occlusion.

When the same tocopherol/tocotrienol concentrate was used to treat patients with intermittent claudication in a controlled clinical trial, the tests showed a significant increase in walking distance before onset of pain, as compared with the group given aspirin or a placebo. A measure of the efficiency of proliferation of their serum lipids was also significantly reduced.

Low-density lipoproteins (LDLs) are involved in the formation of atherosclerotic lesions, which may be exacerbated when the unsaturated fatty acid content in LDL have become oxidized. The antioxidants protect LDL from oxidation.

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In a recent report on lipid oxidation in skeletal muscle induced by exercise, the authors concluded that there was substantial protection against both resting- and exercise-induced protein oxidation by free radical scavenging with vitamin E,

**Table 2.** Cholesterol content of crude oils and fats (references 65 and 66) (cholesterol). (ppm).

<table>
<thead>
<tr>
<th>Oil</th>
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<tr>
<td>Lard</td>
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<td>3500.0</td>
</tr>
</tbody>
</table>

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**Palm oil and serum cholesterol**

Recent controlled human studies in Europe, the USA and Asia have confirmed that serum cholesterol does not increase when palm oil is used to replace the major part of other fats in a traditional diet. This is in contrast to substitution with the more saturated coconut oil.

The amount of cholesterol in the blood is an indicator of risk for cardiovascular disease – and numerous studies have investigated the influence of dietary lipids on blood cholesterol levels.

**Early human studies** indicated that palm oil can reduce the total serum cholesterol level in individuals with hypercholesterolemia, which contributes to hypercholesterolemia. Monounsaturated fatty acids are neutral, but can appear equivalent to polynsaturated when the exchange for linoleic acid is above limiting threshold for that acid.

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(1) A double blind cross-over study was carried out in Holland on 38 men. In this trial 70% of the fat in a normal Dutch diet was replaced by palm oil. The following significant results were obtained.

a) No effect on serum total cholesterol

b) An 11% increase in HDL-C cholesterol
c) An 8% decrease in ratio LDLHDL+dugreides

d) A 9% decrease in LDL-cholesterol

There was an increased incidence in serum apolipoprotein A1 and decreases in apolipoprotein B and the apoB/ apoA1 ratio.

It was concluded that the changes effected by the palm oil rich diet might slightly reduce the cardiovascular risk profile.

(2) In the same project plasma lipoprotein(a) was also measured. There was a highly significant 10% decrease in Lp(a) during consumption of the palm oil rich diet. This result was consistent with those from other independent laboratories (see later in this article).

(3) In a study of 30 middle-aged men, six different fats were fed as ingredients in a normal American diet, forming 60% of the total fat intake. Fat represented 40% of the dietary energy. When palm oil was the test fat, total cholesterol was not affected but HDL-cholesterol (HDL-C) and apolipoprotein A1 increased, while apolipoprotein B decreased relatively to baseline.

(4) Feeding nine men a diet containing 35% of the energy as fat, and one half of the fat as palm oil produced no change in plasma total or LDL-C, but a small rise in HDL-C occurred.

(5) Two trials were reported using 21 and 30 subjects, respectively, in which half the dietary fat intake was supplied as potato crisps fried in the test oil. When palm olein was used there was a 5% increase in plasma HDL-C, which accounted for a 3% rise in total cholesterol.

(6) The effect of palm olein, used as the cooking oil in the preparation of food for 110 high school students, has been reported. They represented a typical Malaysian diet, with 35% of the energy content as fat. The palm olein rich diet did not significantly alter plasma total, HDL-C and LDL-C, but the concentration increased the concentrations of apolipoprotein A1 (+11%) and apolipoprotein B (-9%). The ratio of Apo B to Apo A1 was not significantly affected. It was concluded that there was no adverse effect on fatty acid metabolism.

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(8) Another study, carried out in 33 subjects, used a Malaysian diet with 34% fat calories. When either palm olein or olive oil were fed as 23% energy (about 2/3 of the fat intake) neither fat resulted in a significant difference in serum cholesterol levels compared with the olive oil intake. The data demonstrate the equivalent of palmolic and oleic acids in normal individuals.

The thromboxane/prostacyclin ratio in plasma was significantly reduced in the palm olein dietary period as compared with the olive oil period.

**Palm oil and HDL-cholesterol**

It is noteworthy that several of the studies summarized...
that a palm oil diet fed to hamsters results in a significant increase in the production of pro-inflammatory messenger RNA for the LDL receptor and of Apo A1, therefore, points to two potential beneficial effects of palm oil in reducing cardiovascular risk.

Recently Hayes and co-workers26 have also demonstrated that, in monkeys, dietary myristic acid (14:0) and palmitic acid (16:0) have very different effects on cholesterol metabolism, myristic acid being strongly cholesterolamic. This effect was first noted in humans in 196526 but was subsequently largely ignored.

Hayes and Khoul29 have advanced an hypothesis to explain the differing effects, reported in the literature over three decades, of dietary fatty acids on plasma total cholesterol (TC). It is proposed that: (a) linoleic acid (18:2n-6) ‘up-regulates’ the full receptor activity, allowing LDL-C to be cleared from plasma, while myristic (14:0) acid ‘down-regulates’ the receptors (i.e. lower receptor activity) resulting in a rise of plasma LDL-C. Between 3% and 6.5% of myristic acid as 18:2n-6:14:0 is the only fatty acid to increase plasma LDL-C, while below 3% 14:0 is highly hypercholesterolaemic and 16:0 merely modestly so (Figure 1). These interactions may be further modified by (i) the quantity of cholesterol in the diet – at increasing levels, the sensitivity to saturated fatty acids may be greater, and (ii) the initial concentration of plasma TC, in subjects who are already hypercholesterolaemic may be more sensitive because their LDL receptors are saturated or down-regulated.

The hypothesis, based on initial results with monkeys, has been strengthened by reanalysis of published human data by the same authors, and there appears to be a good ‘fit’ with earlier experimental work. This provides an example of the important nutritional principle of nutrient balance, in this case the balance between different dietary fatty acids and cholesterol.

Palm oil and the proangiogenic/thrombosis balance

In a rat model of arterial thrombosis dietary palm oil performed comparably with other more saturated oils27. The risk of arterial thrombosis is at least partly determined by the potential of platelet activators to synthesize a pro-thrombotic compound, thromboxane, and of the arterial wall to generate the pro-thrombotic substance prostacyclin.28

There is good evidence that palm oil reduces the tendency for thrombi to form in arteries, and that this is mediated by the ability of palm oil to promote a favorable shift in the balance between these substances. This has been demonstrated in rats29 and also in rabbits30. Possible anti-thrombosis action of palm oil

Experimental work on rats, comparing palm oil in the diet with a number of other edible oils, showed that palm oil reduced the number of chemically-induced tumours.

After induced carcinogenesis rats fed palm oil at 20% of the diet had significantly fewer tumours after 50 months than those fed the same level of corn or soya bean.31

In a somewhat earlier study rats fed palm oil at 20% of the diet (before induction of carcinogenesis) showed no greater level of cancer than the ‘controls’ on a 5% corn oil diet. On the other hand, fat from 25% beef or land showed enhanced breast cancer development.32

References

NUTRITIONAL ASPECTS OF PALM OIL

Palm oil and the proestrogenicity/hormone balance

A palm oil diet fed to hamsters results in a significant increase in the production of the 17β-estradiol estrogen receptor mRNA for the LDL receptor and apo A1, therefore, points to two potential beneficial effects of palm oil in reducing cardiovascular risk.

Recently Hayes and co-workers have also demonstrated that, in monkeys, dietary myristic acid (14:0) and palmitic acid (16:0) have very different effects on cholesterol metabolism, myristic acid being strongly cholesterolemic. This effect was first noted in humans in 1965 but was subsequently largely ignored.

Hayes and Khoo in 1988 have advanced an hypothesis to explain the differing effects, reported in the literature over three decades, of dietary fatty acids on plasma total cholesterol (TC). It is proposed that: (a) linoleic acid (18:2n-6) 'up-regulates' the LDL receptor (if activity is in full activity), allowing LDL-C to be cleared from plasma, while myristic (14:0) acid down-regulates' the receptors (ie lower receptor activity) resulting in a rise in plasma TC. Between 3% and 6.5% E as 18:2, 14:0 is the only fatty acid to increase plasma LDL-C, while below 3% E 14:0 is highly hypercholesterolaemic and 16:0 only moderately so (Figure 1). These interactions may be further modified by: (i) the quantity of cholesterol in the diet – at increasing levels, the sensitivity to saturated fatty acids may be greater, and (ii) the initial concentration of plasma TC, in subjects who are already hypercholesterolaemic may be more sensitive because their LDL receptors are saturated or down-regulated.

The hypothesis, based on initial results with monkeys, has been strengthened by reanalysis of published human data by the same authors, and there appears to be a good fit ‘with earlier results with rodents. This provides an example of the important nutritional principle of nutrient balance, in this case the balance between different dietary fatty acids and cholesterol.

Palm oil and the proestrogenicity/hormone balance

In a rat model of arterial thrombosis dietary palm oil performed comparably with other more unsaturated oils. The risk of atheroma formation is at least partly determined by the potential of blood platelets to synthesize a pro-thrombotic compound, thromboxane, and of the arterial wall to generate the thromboxane metabolite, thromboxane A2. There is good evidence that palm oil reduces the tendency for thrombi to form in arteries, and that this is mediated by the ability of palm oil to promote a favourable shift in the balance between these substances. This has been demonstrated in rats and also in rabbits.

Possible antithrombosis action of palm oil

Experimental work on rats, comparing palm oil in the diet with a number of other edible oils, showed that palm oil reduced the number of chemically induced tumours.

After induced carcinogeneces rats fed palm oil at 20% of the diet had significantly fewer tumours after 50 months than those fed the same level of corn or soy bean oil.

In a somewhat earlier study rats fed palm oil at 20% of the diet (before induction of carcinogenesis) showed no greater level of cancer than the controls on a 5% corn oil diet. On the other hand, rats fed 20% beef or fowl rendered showed enhanced breast cancer development.

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Responses of blood glucose and C-peptide to five Chinese starchy foods

Wu Xiaomei MD, HO Zhi-chien PHD, Yu Binjie MD and Weng Jianping MD
Department of Clinical Nutrition, Sun Yat-sen University of Medical Sciences, Guangzhou, China.

Forty-nine patients with non-insulin-dependent diabetes mellitus (NIDDM) were randomly divided into four groups (10-18 patients per group) to compare the responses of blood glucose and C-peptide to some Chinese starchy foods. Ten healthy subjects were used as controls. After an overnight fast, the blood samples were drawn at fasting and 30, 60, 120, 180 minutes postprandially to measure plasma glucose and serum C-peptide levels. Bun, which was made from refined wheat flour and similar to white bread, was used as the assessment as the reference food. Other test foods included rice, lotus seed, seed of gordon erysye, and rhizome of common yam. There was only one kind of food in each test meal, and each consisting contained 50 g of carbohydrates. With both glycaemic index (GI) and C-peptide index (CI) of bun set at 100 in this study, the GI and CI respectively were: rice 89 and 91; lotus seed 62 and 72; seed of gordon erysye 102 and 102; rhizome of common yam 103 and 95. The GI and CI of lotus seed were significantly lower than those of other test foods. It appears that lotus seed may have a beneficial effect in NIDDM patients, and may be one of the more appropriate foods for diabetic patients.

Introduction

With the liberalization of carbohydrate intake in diabetic patients, many studies have focused on postprandial glycaemic response and carbohydrate-rich foods. It is known that different foods with the same amount of carbohydrate may produce different glycaemic responses. The glycaemic index, an indicator of post-prandial glycaemic response to food, is widely used in conjunction with this. In this study we exchange list in planning diabetic diets, especially in selecting starchy foods.

Some Chinese starchy foods (eg lotus seed, seed of gordon erysye, rhizome of common yam etc), according to traditional Chinese Medicine, are regarded as both edible foods and effective herbal medicines for diabetes, and have been recommended in China as alternative staple foods for diabetics. On the other hand, bun and rice are two main staple foods in China. Whether any of these foods can produce a lower glycaemic response needs to be determined. In this study we observed the blood glucose and C-peptide responses to these Chinese starchy foods in diabetic and healthy subjects, in order to determine which of these foods is more appropriate for inclusion in a diabetic diet.

Subjects and methods

Subjects included 49 volunteer non-insulin-dependent diabetes mellitus (NIDDM) patients (25 male and 24 female) and ten healthy volunteers (five male and five female). The age of the subjects, the body mass index (BMI), the fasting plasma glucose level and daily therapy are shown in Table 1.

Ethics statement

The patients were randomly divided into four groups (10-18 patients per group), while all the healthy persons comprised a single control group. The studies were conducted on two mornings in NIDDM patients and three mornings in healthy subjects. After a 10-hour overnight fast, an intravenous cannula was placed in the forearm vein of the subject. A test meal was consumed within 15 minutes. The test meal was bun for all groups on the first test morning and either rice (Oryza sativa subsp. Japonica), lotus seed (Nelumbo nucifera), seed of gordon erysye (Euryale ferox) or rhizome of common yam (Dioscorea opposita) for each test group, on the second test morning in NIDDM subjects. For healthy subjects the test meal was also bun on the first test morning, rice on the second, and lotus seed on the third. Among these five test foods, bun which was made from refined wheat flour and similar to white bread, was served as the reference food. The other foods (rice, lotus seed, seed of gordon erysye, and rhizome of common yam) were prepared by the laboratory staff in small unit size. Each serving consisted of only one kind of test food and contained 50 grams of carbohydrate. Table 2 shows the composition of the test foods.

During the test morning, all subjects rested and consumed no extra foods, but took a sip of water once in a while. Neither oral hypoglycaemic agents nor regular insulin was used in NIDDM subjects. Blood samples were drawn at fasting and after 30, 60, 120, 180 minutes post-prandially via intravenous cannula, for measuring glucose and C-peptide levels. Plasma glucose was determined using the glucose oxidase method.

Correspondence address: Wu Xiaomei, Department of Nutrition, Nankai Hospital, Guangzhou, P.R. China.