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Fall in total cholesterol concentration over five years in association with changes in fatty acid composition of cooking oil in Mauritius: cross sectional survey

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Abstract

***Objective*—To determine the extent to which reducing the saturated fatty acid composition of a ubiquitously used cooking oil influenced changes in cholesterol concentration in the population during a five year intervention programme in Mauritius.**

***Design*—Cross sectional surveys in 1987 and 1992 determined mean total cholesterol concentrations in the population. A random sample of respondents in the 1992 survey completed a nutrition questionnaire that included questions on diet in the previous 24 hours.**

***Setting*—Mauritius.**

***Intervention*—In 1987 the government of Mauritius changed the composition of the commonly used cooking oil from being mostly palm oil (high in saturated fatty acids) to being wholly soya bean oil (high in unsaturated fatty acids).**

***Subjects*—5080 and 5162 subjects in 1987 and 1992 cross sectional surveys. 2059 subjects aged 30-64 years were randomly selected from the respondents of the 1992 survey to take part in the nutrition survey**

***Main outcome measures*—Fatty acid composition of phospholipids in pooled serum samples from men and women from the two surveys; measured and predicted change in serum cholesterol concentration.**

***Results*—From 1987 to 1992 total cholesterol concentrations fell significantly by 0.79 mmol/l (P<0.001) in men and 0.82 mmol/l (P<0.001) in women. The estimated intake of saturated fatty acids decreased by 3.5% of energy intake in men and by 3.6% in women, and the intake of polyunsaturated fatty acids increased by 5.5% and 5.6% of energy intake, respectively. These changes were reflected in changes in the fatty acid composition of serum phospholipids, and according to Keys' formula these changes explained much of the decrease in serum cholesterol concentrations (predicted decrease of 0.38 mmol/l in men and by 0.40 mmol/l in women).**

***Conclusion*—Dietary changes that entailed a reduction in the saturated fat content of a ubiquitous cooking oil explained most of the observed decrease in serum cholesterol concentration over five years in the population of Mauritius.**

Introduction

In 1987 the government of Mauritius launched a non-communicable diseases intervention programme to prevent and control diseases caused by unhealthy lifestyles because such diseases were occurring at increasing rates in Mauritians.[1,2] A national survey in 1987 had confirmed high levels of cardiovascular risk factors and a high prevalence of diabetes in the population.[3-5] As well as promoting healthy lifestyles,[2] the government also limited the content of palm oil in the cooking oil used almost universally in Mauritius ("ration oil"). Palm oil is high in saturated fatty acids and was then the main component of ration oil. The

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Table 1—*Proportional use of cooking fats, fatty acid composition of average cooking fat, and change in fatty acid intake in Mauritius, 1987-92*

	Average fat composition/ 100 g cooking fat	Saturated	Monounsaturated	Polyunsaturated
Proportional use of cooking fats in 1987:				
86% Ration oil	75 g palm oil	34.0	31.2	6.2
14% Soya bean oil	25 g soya bean oil	3.5	6.1	14.2
Total		37.5	37.3	20.4
Proportional use of cooking fats in 1992:				
53% Modified ration oil*				
46% Soya bean oil	99 g soya bean oil	13.9	24.0	56.2
1% Other	0.6 g ghee	0.5	0.0	0.0
	0.4 g polyunsaturated margarine	0.1	0.1	0.2
Total		14.5	24.1	56.4
Change in fatty acids, 1987-92, per 100 g cooking fat (g)†		−23.0	−13.2	36.0
Mean intake in 1992 (% of energy intake):				
Men		7.0	7.5	8.6
Women		7.5	7.8	8.8
Mean change in intake, 1987-92 (% of energy intake)				
Men		−3.5	−2.0	5.5
Women		−3.6	−2.1	5.6

*Fat composition of ration oil changed between 1987 and 1992.
†Assuming no other changes in diet but composition of ration oil.

composition of ration oil changed dramatically from 1987, when it was 75-100% (median 87.5%) palm oil, to 1992, when it was wholly soya bean oil.

In 1992 we performed a follow up survey and also a nutrition survey to determine whether the changes in fatty acid composition of cooking oil had influenced the considerable decrease in the mean cholesterol concentration in the population—from 5.5 mmol/l in 1987 to 4.7 mmol/l in 1992[6]—during the five year intervention programme in Mauritius.

Subjects and methods

The main survey cohorts comprised 5080 people in 1987 and 5162 people in 1992.[6] For the nutrition survey we randomly selected a subsample of 2059 subjects aged 30-64 years (stratified by age, sex, and ethnic group) from the respondents in the 1992 survey.[6] The overall response rate was 95%, and after data quality checks and exclusion of unclear data the final number of respondents was 1926.

We asked people to recall what they had eaten during the previous 24 hours to obtain information about dietary intake. In April 1988 a random subsample of 1115 respondents in the 1987 survey[3 6] had been asked the type of fat used for cooking in a health knowledge and attitudes questionnaire. Participants in the nutrition survey in June-July 1992 completed a similar questionnaire.

We calculated the predicted serum total cholesterol concentration in the study population and changes in it over time according to dietary fat intake using the Keys equation.[7 8] No quantitative data on dietary intake data in invidual people were collected in 1987. We assumed that no major dietary changes other than those in the composition of ration oil had occurred from 1987 to 1992.

The fatty acid composition of phospholipids was measured in stored serum samples by the method of Houwelingen *et al*[9] at the department of human biology of the University of Limburg, the Netherlands, in 1994 to investigate whether modifying the dietary intake of fatty acids had affected serum concentrations. Samples were pooled from 25 randomly selected normoglycaemic participants for analysis. In all there were 16 pooled samples (from a total of 400 participants), four from men and four from women in each of the 1987 and 1992 surveys. To avoid confounding in lipid metabolism and diet between ethnic groups, only Hindu Indians were selected because they are the predominant ethnic group in Mauritius.

Table 2—*Daily dietary intake of cholesterol and predicted and measured serum cholesterol concentrations in Mauritian men and women, 1987-92*

	Men		Women	
	1992	Change from 1987 to 1992	1992	Change from 1987 to 1992
Dietary cholesterol (mg/4.2 MJ/day)	85.7	0	85.3	0
Serum cholesterol (mmol/l):				
Predicted*	4.89	−0.38	4.92	−0.40
Measured	4.78	−0.79	4.65	−0.82

*According to the method of Keys *et al*.[7] For concentration (mg/dl) equation is 168 + 1.35(2 × percentage of saturated fatty acids–percentage of polyunsaturated fatty acids) + 1.5 × √dietary cholesterol intake. For change (mg/dl) equation is 1.2(2 × change in percentage of saturated fatty acids–change in percentage of polyunsaturated fatty acids) + 1.5 × √change in dietary cholesterol intake.

Table 3—*Mean relative percentages of selected fatty acids in pooled serum samples from normoglycaemic Hindu Indians, 1987 and 1992*

	Men		Women	
Fatty acid (formula)	1987	1992	1987	1992
Palmitic ($C_{16:0}$)	32.7	28.2***	33.1	27.1***
Palmitoleic ($C_{16:1n-7}$)	0.49	0.40*	0.43	0.34**
Oleic ($C_{18:1n-9}$)	9.29	6.11***	8.30	5.44***
Linoleic ($C_{18:2n-6}$)	18.2	21.6***	18.2	22.1***
Linolenic ($C_{18:3n-3}$)	0.14	0.22**	0.12	0.20**
Arachidonic ($C_{20:4n-6}$)	5.56	8.68***	5.18	8.54***
Eicosapentaenoic ($C_{20:5n-3}$)	0.56	0.89**	0.42	0.82**
Other	33.1	33.9*	34.2	35.5**

*P<0.05.
**P<0.01.
***P<0.001.

Results

Ration oil was used by 86% (867) of the respondents in 1988 and by 53% (1285) in 1992 (table 1). According to the 24 hour recall data, the mean daily total fat intake per person was 56.2 g, supplying 25.4% (SD 6.7%) of energy intake in men and 26.4% (7.0%) in women. Sixty six per cent of the total fat intake came from cooking fat. Assuming that other aspects of diet remained unchanged, the estimated mean reduction in the saturated fatty acid intake from 1987 to 1992 related to changes in intake of cooking fat was 3.5% of energy intake in men and 3.6% in women (table 1). The corresponding figures for monounsaturated fatty acids were 2.0% and 2.1% of energy intake, whereas the intake of polyunsaturated fatty acids increased by 5.5% and 5.6% of energy intake, respectively.

Key messages

- The high prevalence of cardiovascular diseases is a remarkable problem in Mauritius
- The saturated fatty acid intake of Mauritians was reduced by modifying the composition of the widely used cooking oil
- Mean serum cholesterol concentration decreased by 15% after the cooking oil intervention was introduced nationwide
- Effective, low cost prevention programmes for chronic disease are needed in less industrialised countries. Simple action in dietary policy could be one such strategy

Using the formula of Keys *et al*[7] we calculated that such changes would result in a reduction in the total cholesterol concentration of 0.38 mmol/l in men and 0.40 mmol/l in women (table 2). The measured mean cholesterol concentrations in 1992—4.78 mmol/l in men and 4.65 mmol/l in women—agreed well with those predicted.

The observed dietary changes were reflected in the changes in the fatty acid composition of the serum phospholipids between 1987 and 1992 (table 3). There was a significant decrease in the relative proportion of palmitic ($C_{16:0}$) and palmitoleic ($C_{16:1n-7}$) acid, whereas the percentage of polyunsaturated fatty acids such as linoleic acid ($C_{18:2n-6}$) increased substantially.

Discussion

The mean total cholesterol concentration decreased by 14-15% among adult Mauritians during the five years from 1987 to 1992.[6] At the same time the composition of fatty acids in the most commonly used cooking oil was changed favourably. This change was intentional and abrupt and affected the entire population. This evidence is based on qualitative dietary data and supports the hypothesis that the change in cooking oil was the main dietary change during this period.

The change in the composition of ration oil was monitored by the government laboratory. The resulting change in fatty acid intake was reflected in changes in the composition of phospoholipids in serum. Specific fatty acid concentrations in blood, cell membranes, and subcutaneous fat are reliable indicators of dietary fat intake during the previous month.[10] With the method of Keys *et al*[7] we showed that the change in fatty acid intake calculated from the dietary data explained a considerable part of the observed reduction in total cholesterol concentration.

The effects of palm oil on serum cholesterol concentration have been studied in several randomised trials.[11-13] The main dietary fatty acids that increase cholesterol concentrations are saturated and have from 12 to 16 carbons (lauric acid ($C_{12:0}$) to palmitic acid ($C_{16:0}$)).[7]

Whether the replacement of palm oil by soya bean oil, rich in n-6 polyunsaturated fatty acids, is the optimal dietary change may be questioned. Monounsaturated fatty acids of the *cis* configuration, such as oleic acid found in olive oil, reduce concentrations of total cholesterol and low density lipoprotein cholesterol when used instead of saturated fatty acids.[14] More importantly, the consumption of fats high in polyunsaturated fatty acids may lead to increased concentrations of free radicals and oxidised low density lipoprotein,[15] which may promote the progression of atherosclerosis.[16] Therefore, not withstanding the apparent success of the intervention in Mauritius, an oil high in monounsaturated fatty acids, such as olive oil or rapeseed oil, might be preferable if such an oil substitution were currently being planned.

Our data show that a single public health intervention—the reduction in the saturated fat content of an almost universally used cooking oil—was responsible for much of the large decrease in total cholesterol concentrations in the population of Mauritius. To introduce such changes in most countries may, however, be difficult both technically and politically. Nevertheless, these data show clearly the important effects that relative changes in fatty acid consumption can have on serum lipid profile. Legislative and other regulatory control of fatty acid composition of cooking oils and fats may have important effects and may be more effective than public health education alone.

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Correction

Peanut allergy in relation to heredity, maternal diet, and other atopic diseases: results of a questionnaire survey, skin prick testing, and food challenges

Two authors' errors occurred in this paper by J O'B Hourihane and others (31 August, pp 518-21).

Firstly, the third and fourth sentences in the second paragraph of the results should have read: "Mc Nemar's χ^2 analysis of parental concordance showed that asthma was equally common in mothers and fathers ($\chi^2 = 0.17$, P = 0.67, 95% confidence interval 0.07 to 1.53, odds ratio 1.0). Hay fever was also equally common (0.54, P = 0.46, 0.86 to 1.41, 1.1). Eczema was more common (5.73, P = 0.01, 1.07 to 2.1, 1.5) and any food allergy twice as common (13.14, P = 0.0003, 1.31 to 2.57, 1.82) in mothers."

Secondly, the third sentence of the second paragraph of the discussion should have read "twice as likely" rather than "more than four times as likely."