EFFECTS OF RAPESEED OIL ON THE FATTY ACID COMPOSITION OF PLASMA PHOSPHOLIPIDS IN BUTTER AND VEGETABLE FAT USERS

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INTRODUCTION

Zero erucic acid rapeseed oil has a versatile fatty acid composition consisting of high amounts of monoenoic oleic acid and a moderate content of essential linoleic (18:2, LA) and α-linolenic acids (18:3, α-LLA). The cholesterol-lowering effect has been attributed to the monoenes (MUFA), whereas polyenoic fatty acids (PUFA) are rather responsible for the antithrombotic effects (McDonald et al. 1989; Weaver et al. 1990).

α-Linolenic acid has an important function in increasing plasma eicosapentaenoic acid (EPA) levels (Renaud et al. 1986; Weaver et al. 1990). On the other hand, being an easily oxidizing compound, α-LLA is technically undesirable. Breeding work, aimed at changing the fatty acid composition of rapeseed oil, is therefore also directed at decreasing the α-LLA content (Rakow 1973). LA plays an even more important role in the diet. Population studies suggest that a low intake of LA, as in Finland for example, is associated with a high incidence of coronary heart diseases (Logan et al. 1978; Riemersma et al. 1986). A low proportion of PUFA in serum phospholipids is also presumed to be a risk factor (Miettinen et al. 1982).

The aim of this study was to examine the effects of rapeseed oil substitution on the fatty acid composition of plasma phospholipids in butter and vegetable fat users. Groups using margarine and olive oil were also included for comparison.

SUBJECTS AND METHODS

One hundred healthy volunteers participated in the study. Subjects who normally used butter on bread were divided into rapeseed oil (N = 20) and margarine groups (N = 23). Vegetable fat users formed the rapeseed oil (N = 23) and olive oil groups (N = 23). During the first 6-week period the fat on bread was replaced by these fats (Table 1).

Table 1. Fatty acid composition (%) of the substitute fats.

Fatty acids	10:0-14:0	16:0	18:0	18:1c	18:1tr	18:2	18:3	Others
Rapeseed oil	0.1	3.3	1.5	57.2	-	24.3	10.1	3.5
Tested margarine	4.5	8.0	7.2	31.1	16.4	28.1	2.7	2.0
Olive oil	0.1	10.6	2.7	74.6	-	9.1	1.2	1.7

Oils were given as water/oil emulsions (fat content 65%). No other dietary changes were made. Substitute fats accounted

for 18% of total fat and 7% of total energy intake, on the average. After substitution the subjects returned to using butter or vegetable fat on bread. A control group (N = 11) consisting of both butter and vegetable fat users followed their habitual diet during the trial. Fasting blood samples were taken at the baseline and at 3, 6 and 12 weeks. The use of substitute fats was verified by total plasma fatty acid analysis. Plasma phospholipids were separated by TLC, and fatty acids analysed using optimized GC methods (Seppänen-Laakso et al. 1990). Statistical differences in the total plasma and phospholipid fatty acid levels were analysed by the paired t-test.

RESULTS AND DISCUSSION

Substitution and Total Plasma Fatty Acids

Rapeseed oil substitution caused a significant increase in the proportion of total plasma α-LLA (Fig. 1a). This increase was dose dependent (Fig. 1b). Rapeseed oil and the tested margarine also raised the LA level in butter users, but no significant changes were found in the proportion of oleic acid. The use of olive oil was clearly reflected in the proportion of total plasma oleic acid.

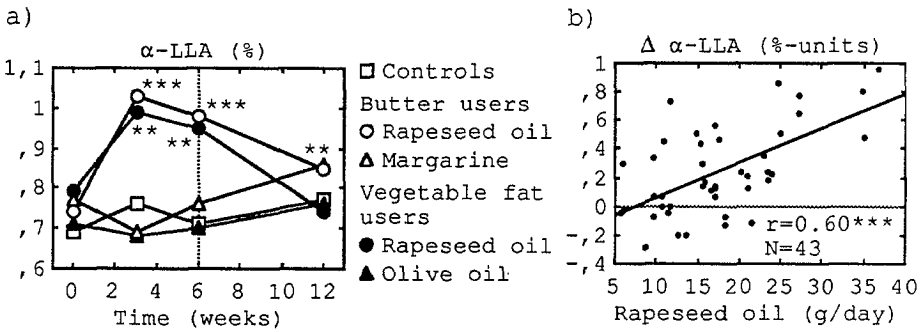

Fig. 1. Changes in the proportion of α-LLA in total plasma (a), and correlation with the daily dose of rapeseed oil (b). ***p<0.001, **p<0.01.

Effect on Phospholipid Fatty Acids

The reduced intake of butter considerably decreased the proportion of SaFA (Table 2). A significant increase in n-3 PUFA, especially in EPA levels, occurred during rapeseed oil substitution (Fig. 2a), whereas the proportion of n-6 PUFA increased at 6 weeks with a simultaneous decrease in MUFA. The results show that both α-LLA and LA, rather than MUFA, are primarily utilized for further fatty acid metabolism. These changes also follow the competitive order of the unsaturated fatty acid families (n-3 > n-6 > n-9)(Holman 1986). The tested margarine, which contained 28% of LA and 3% of α-LLA (Table 1), caused a significant increase in n-6 PUFA but had no effect on n-3 PUFA levels (Table 3).

The most significant changes during the first 3 weeks when vegetable fat on bread was replaced by rapeseed oil were the decrease in SaFA and increase in MUFA (Table 2). However, the level of LA remained unchanged. Rapeseed oil substitution raised the EPA levels also in vegetable fat users (Fig. 2b).

Table 2. Fatty acid composition (%) of plasma phospholipids in the rapeseed oil and control groups during the study.

Group	SaFA	MUFA	n-6 PUFA LA	n-6 PUFA Total	n-3 PUFA α-LLA	n-3 PUFA EPA	n-3 PUFA Total
Rapeseed oil substitution (earlier butter users)							
Baseline	46.5	15.2	20.5	30.7	0.4	1.5	7.6
3 weeks	43.6↓↓↓	15.3	21.0	31.8	0.7↑↑↑	1.9↑↑	9.3↑↑↑
6 weeks	44.9↓↓	12.9↓↓↓	21.4	32.8↑↑↑	0.5	2.0↑↑	9.3↑↑↑
12 weeks	44.8↓↓	15.3	20.0	31.7	0.4	1.7	8.2
Rapeseed oil substitution (earlier vegetable fat users)							
Baseline	44.8	13.8	22.1	32.9	0.4	1.5	8.5
3 weeks	43.0↓↓↓	15.7↑↑↑	21.6	31.8↓	0.7↑↑↑	2.1↑↑	9.5↑↑
6 weeks	44.3	12.8↓↓↓	22.4	33.8↑	0.4	1.8↑	9.0
12 weeks	45.2	15.5↑↑↑	22.0	31.8↓↓	0.4	1.6	7.4↓↓
Controls							
Baseline	44.4	14.1	23.1	33.7	0.5	1.4	7.9
3 weeks	43.5↓	14.5	22.4	33.1	0.6	1.7	9.0
6 weeks	44.2	13.4↓	23.3	34.0	0.4	1.5	8.4
12 weeks	43.3↓↓	15.7↑↑	23.4	33.3	0.5	1.4	7.6

Paired t-test, $p<0.001$(↑↑↑,↓↓↓), $p<0.01$(↑↑,↓↓), $p<0.05$(↑,↓) compared to the baseline.

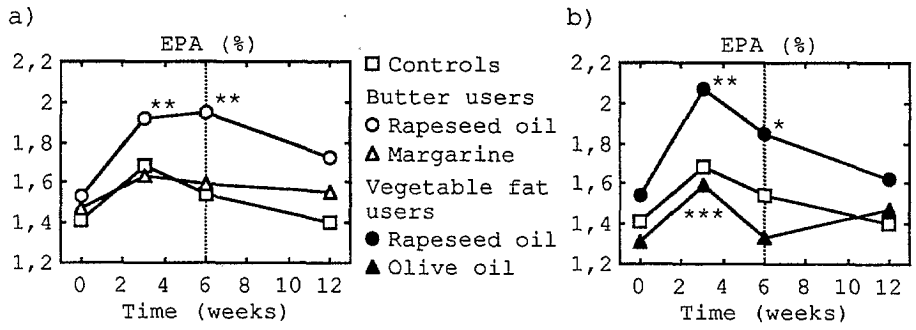

Fig. 2. The proportion of EPA in plasma phospholipids in the substitution and control groups. ***p<0.001, **p<0.01, *p<0.05.

The results indicate that α-LLA is capable of increasing the proportion of EPA even at a low degree of rapeseed oil substitution. A simultaneous fall in SaFA probably further promotes the metabolism of α-LLA. Furthermore, rapeseed oil lowered the serum LDL-cholesterol level in vegetable fat users by 5%, on the average (Seppänen-Laakso et al. 1989). It is of special interest that the increase in the proportion of α-LLA in phospholipids was associated with a decrease in LDL-cholesterol ($r = -0.43$, $p<0.05$, $N = 23$).

Olive oil substitution resulted in an increase ($p<0.01$) in the phospholipid MUFA level (Table 3). However, the proportion of LA remained significantly lower during the substitution period, which may not be desirable if the intake of LA is low.

Table 3. Effects of margarine and olive oil substitution on phospholipid fatty acids.

Group	SaFA	MUFA	n-6 PUFA LA	n-6 PUFA Total	n-3 PUFA EPA	n-3 PUFA Total
Margarine substitution (earlier butter users)						
Baseline	45.3	14.4	21.8	32.4	1.5	7.9
3 weeks	43.9↓↓	13.9	22.9↑	33.7↑↑	1.6	8.5
6 weeks	44.7↓	13.6↓	22.8	33.6↑	1.6	8.1
12 weeks	46.3	14.1	21.4	32.0	1.5	7.6
Olive oil substitution (earlier vegetable fat users)						
Baseline	44.3	14.1	23.6	33.8	1.3	7.7
3 weeks	44.0	14.9↑↑	22.6↓↓	32.9↓	1.6↑↑↑	8.2↑
6 weeks	43.9↓	15.2↑↑	22.4↓	33.3	1.3	7.6
12 weeks	44.7	13.5↓	23.6	34.1	1.5	7.7

Paired t-test, $p<0.001$(↑↑↑,↓↓↓), $p<0.01$(↑↑,↓↓), $p<0.05$(↑,↓) compared to the baseline.

CONCLUSIONS

The results demonstrate that rapeseed oil, even at a low degree of substitution, increases the level of polyunsaturated fatty acids in plasma phospholipids. Despite its moderate content of linoleic and α-linolenic acids, rapeseed oil can be primarily a source of essential fatty acids, rather than that of monoenes, in the diet of butter users. The function of α-linolenic acid as the precursor of n-3 polyunsaturated fatty acids is especially significant in the diet of both butter and vegetable fat users.

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