Food Quality of Rapeseed Oil - Aspects from a Nutritional Point of View

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The prevailing opinion up to the study of Mattson and Grundy in 1985 stated that dietary saturated fatty acids raised, polyunsaturated fatty acids (PUFA) lowered and monounsaturated fatty acids (MUFA) had practically no effect on plasma cholesterol concentrations in humans (Hegsted et al., 1965, Keys et al., 1965). Subsequent studies have demonstrated that oleic acid-rich oils, namely olive oil, rapeseed oil or high-oleic safflowerseed or sunflowerseed oil were equally effective in lowering total and LDL cholesterol as linoleic-acid rich oils, e.g. sunflowerseed oil, soyabeen oil and safflowerseed oil (McDonald et al., 1989; Mensink & Katan, 1989; Wardlaw et al., 1991; Valsta et al., 1992; Gustafsson et al., 1994; Nydahl et al., 1994; Valsta et al., 1995). In addition, studies using animal models intended to evaluate the specific effect of dietary fat rich in MUFA on cholesterol metabolism (Fernandez et al., 1992 and 1996; Trautwein et al., 1997).

Rapeseed oil used to have a bad reputation concerning its nutritional quality due to the high content of erucic acid (C22:1). Today, because of the developments in plant breeding, rapeseed varieties with the erucic acid content reduced from 40% to almost 0% are available ('00' rapeseed quality). These positive developments in the fatty acid composition have made rapeseed oil to a preferable vegetable oil in human nutrition. In the USA, Canada and in the Scandinavian countries rapeseed oil (canola oil) is widely accepted as a highly nutritious dietary fat source. In 1987 canola oil was named "Product of the Year" by the American Health Foundation and in 1988 it was given the "Product Acceptance Award" by the American College of Nutrition. Rapeseed oil is not only used as cooking or salad oil but is also an important ingredient of a wide variety of food products such as margarine, spreads, mayonnaise, salad dressings, baked goods, convenience foods and infant formulas.

Criteria for a nutritious ('healthy') vegetable oil

Several aspects concerning the quality of a 'healthy' fat or oil for its use as a dietary fat source are summarized in **Table 1**. In addition to a favorable fatty acid composition other aspects regarding taste, smell and flavor as well as functional properties, i.e. a broad suitability for its use in food preparation are also important.

Table 1: Criteria for a nutritious ('healthy') dietary fat source

* low in saturated fatty acids, especially in lauric acid, myristic acid and palmitic acid
* adequate in the n-6 and n-3 essential fatty acids such as linoleic acid and α-linolenic acid
* preferentially a good source of MUFAs, i.e. oleic acid
* low content or virtually free of trans fatty acids
* rich in vitamine E (tocopherols) and other antioxidative compounds
* neutral or good taste, acceptable flavor
* generally suitable for a wide range of use, e.g. use as salad oil and for various cooking procedures and food preparations

Comparison of rapeseed oil with other commonly used vegetable oils

Compared to other vegetable fats and oils, rapeseed oil has a distinct fatty acid composition: it is extremely low in saturated fatty acids and is an important source of the monounsaturated oleic acid (18:1 n-9) which is with about 60% the most abundant fatty acid (**Table 2**). In addition, rapeseed oil is a good source of the essential fatty acids linoleic acid (18:2 n-6) and especially of the n-3 fatty acid α- linolenic acid which together account for about 30% of total fatty acids. Besides in rapeseed oil, α- linolenic acid is only present in higher concentrations in soyabean and linseed oil. In addition to its favorable fatty acid composition, rapeseed oil contains an adequate concentration (40 mg/100 g) of tocopherols and has a high content of plant sterols, e,g. ß-sitosterol which may also contribute to the positive impact of rapeseed oil in lowering plasma cholesterol.

Table 2: Comparison of rapeseed oil with other vegetable oils

* lowest content of saturated fatty acids 6-8% of total FAs
* high in MUFA, oleic acid 18:1 n-9 58-60% of total FAs
* rich source of essential fatty acids linoleic acid 18:2 n-6 20-26% of total FAs and α-linolenic acid 18:3 n-3 10-12% of total FAs
* rich in plant sterols (i. e. ß-sitosterol and campesterol) 450-1000 mg /100 oil

Because of the increasing recognition of the advantages of MUFA-rich oil, classical PUFA-rich oil sources such as sunflowerseed or safflowerseed are nowadays also available as oleic acid enriched varieties. A comparison of the fatty acid profiles as well as the plant sterol concentrations of various MUFA-rich oils is summarized in **Table 3**.

Table 3: Fatty acid comparisons[a] and plant sterol concentrations of different MUFA-rich oils

Fatty acid	Rapeseed oil	Olive oil	Trisun (18:1-rich sunflowerseed oil)	18:1-rich safflowerseed oil	Peanut oil
	fatty acid composition as a percentage of total fatty acid contents				
Palmitic acid	4.5	12.5	3.6	3.5	10.0
Stearic acid	1.5	2.5	4.0	5.0	3.0
Oleic acid	60.0	72.5	81.4	81.5	42.0
Linoleic acid	20.0	9.8	9.0	7.5	38.0
α-Linolenic acid	9.5	0.6	0.1	0.1	0
			mg/100 g		
Total plant sterols	492[b]	72[b]	135[b]	na	240[c]
ß-sitosterol	227[b]	68[b]	100[b]	na	179[c]
Campesterol	199[b]	3[b]	14[b]	na	29[c]

[a] pooled data from own analyses and from various fatty acid composition tables
[b] own unpublished data; na= no data available
[c] from nutrient tables (Souci, Fachmann, Kraut: Food composition and Nutrition Tables, 1994)

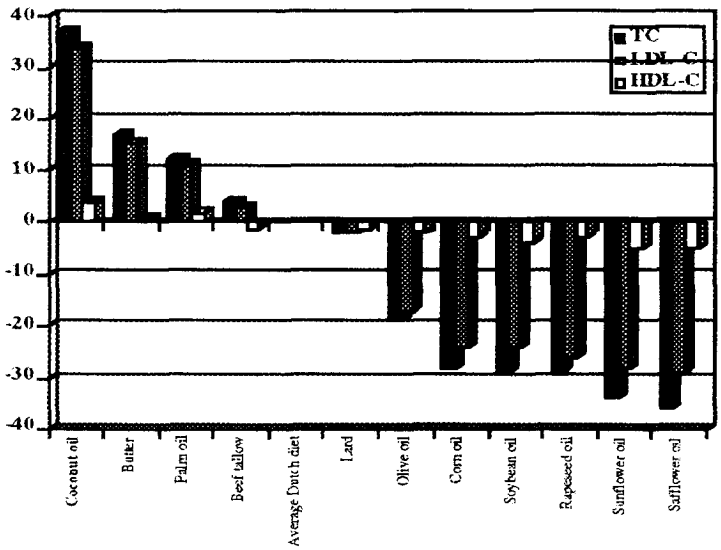
Nutritional aspects of rapeseed oil

From a nutritional perspective rapeseed oil has several considerable advantages which are summarized in **Table 4**. A recent meta analysis (Gardner & Kraemer, 1995) has documented that there are no significant differences in the effect on total, LDL- and HDL-cholesterol in response to a dietary exchange of oils high in MUFAs or PUFAs under conditions when fat intake is derived primarily from common vegetable oils. In an overview of the effects of fatty acids on blood lipids in humans, Katan et al. (1994) have calculated the effects on plasma cholesterol when all the fat plus the fat-associated cholesterol in the average Dutch diet was replaced by a particular fat or oil. As a result, depicted in **Figure 1**, they found that lowest total and LDL cholesterol concentrations could be expected with rapeseed oil and the oils rich in linoleic acid (corn, soyabeen, sunflowerseed or safflowerseed oil).

Table 4: Nutritional qualities of rapeseed oil (canola oil)

* Rapeseed oil is a widely accepted nutritious dietary fat source in USA, Canada and the Scandinavian countries. Currently, rapeseed oil is becoming more popular in Germany
* Rapeseed oil rich diets are as effective as PUFA-rich diets in lowering total and LDL-cholesterol without affecting HDL-cholesterol. Therefore the LDL/HDL ratio is favorably affected
* Oleate enriched LDL is also less susceptible to oxidative modification than LDL rich in PUFA and this may lower its atherogenicity. Thus, rapeseed oil rich diets could be beneficial in protecting against the development of atherosclerosis
* Rapeseed oil provides α-linoleic acid as precursor of the n-3 FA family. There is increasing evidence of beneficial effects of n-3 FAs on health and disease prevention i.e in cardiovascular disease, inflammatory and rheumatic diseases and on immune function Thus, nutritionists recommend that the n-6/n-3 FA ratio in the diet should be improved. Rapeseed oil is a potenial source of 18:3 n-3 and could possibly be used for the enrichment of various food products e.g. margarines, spreads or milk infant formulas with n-3 FAs

Figure 1: Predicted effect on plasma cholesterol when 100 g of a particular fat or oil replaces all the fat and fat-associated cholesterol (150 mg) in an average Dutch diet (Data adapted from Katan et al., 1994)



Average Dutch diet:
100g fat /d, 2300 kcal/d
300 mg chol. (150 mg from fats and 150 mg from eggs, meats etc.

Effects of fatty acids were calculated using the "Mensink and Katan equation"

Effect of cholesterol was calculated using the "Keys equation"

Moreover, besides lowering total and LDL cholesterol other aspects such as the pathophysiological importance of lipid peroxidation or regulation of thrombosis and haemostastis are known to be influenced by different types of fatty acids. In fact, diets high in MUFA might enhance the resistance of plasma LDL-cholesterol against oxidative modifcation. Recent studies have shown that by increasing the oleic acid content of LDL these lipoprotein becomes less prone to undergo lipid peroxidation. Therefore, the atherogenicity of LDL could be reduced by diets rich in oleic acid.

Recommendations regarding fat intake in respect to reducing chronic disease risk

Changes in fat intake should include both a reduction of the total fat consumed and a modification of the fat composition. Recommendations for the intake of dietary fats and oils were summarized in the recent Report of a Joint Expert Consultation by the FAO/WHO and are presented in **Table 5**. In addition to the modifications in fat intake, the intake of complex carbohydrates and dietary fibers should also be increased.

Based on guidelines of the European Atherosclerosis Society and the American Heart Association the distribution of saturated fatty acids, MUFA and PUFA should be: no more than 10% of energy as saturated fatty acids, 7-10% of energy as PUFA and 10-15% of energy as MUFA based on a total fat intake of 30% of energy.

In most northern European countries including Germany, the intake of MUFA (mainly oleic acid) is already relatively high and accounts in Germany for 16% of the total energy intake. However, MUFAs are consumed mainly in form of animal products and are therefore associated with a high intake of saturated fatty acids. To reduce the intake of saturated fatty acids from

currently 18% to under 10% of energy, changes in food consumption have to be made especially regarding fat-rich products such as animals fats, meats and dairy products. To avoid that the intake of MUFA will also decrease to less than 10% of energy vegetable oils rich in MUFA such as rapeseed oil are recommended as dietary fat source. Using rapeseed oil will increase the intake of MUFA without raising the intake of saturated fatty acids, while further providing essential fatty acids, especially in regard to the intake of α-linolenic acid (18:3 n-3). Because of their partly antagonistic effects on blood coagulation, blood pressure regulation and immune function, the optimal ratio of n-6 to n-3 fatty acids is another important factor in human nutrition. Therefore, nutritionist recommend that this ratio should be reduced from 10:1 to around 5:1. From these point of view rapeseed oil is a recommenable dietary fat source to increase the n-3 fatty acid intake.

Table 5: Fats and oils in human nutrition - Recommendations summarized in the Report of a Joint Expert Consultation organized by the FAO/WHO, FAO Food and Nutrtion Report 57, 1994

* **Upper limit of fat and oil intake** up to 35% of energy from fat in active individuals no more than 30% of energy from fat in sedentary individuals
* **Saturated fatty acids and PUFA** no more than 10% of energy from saturated fatty acids between 4 and 10% of energy from linoleic acid
* **Dietary cholesterol intake** less than 300 mg/day
* **n-6/n-3 fatty acid ratio** ratio of n-6 18:2 to n-3 18:3 should be between 5:1 and 10:1 Individuals with a dietary ratio greater than 10:1 should eat more n-3 rich foods

Technological aspects

Because of its high quality and favorable fatty acid composition rapeseed oil has gained a good reputation as a highly nutritious vegetable oil not only in the USA, Canada and the Scandinavian countries but also in the meantime in Germany. However, from a technological point of view other criteria such as functionality and oxidative stability for its use in food processing and food technology are important. Because of plant breeding and genetic modifications, specifically designed rapeseed oil varities with a modified fatty acid composition meeting potential users product specifications are already introduced or will be available in the future. For instance, rapeseed oil with a reduced α-linolenic acid content from 10% to about 3% is already available and the nutritional properties of low α-linolenic acid rapessed oil have been evaluated. Because low α-linolenic acid rapeseed oil has been found more stable to oxidation than regular rapessed oil, this variety has some advantages in food applications where a high oxidative and frying stability is demanded by the food industry. Another direction is the development of rapeseed varieties with reduced PUFA and increased oleic acid contents providing rapessed oil with more than 80% oleic acid.

Specifically designed rapeseed oils with a modified fatty acid profile can possibly be used for specific application in the food industry where certain functional properties are required but do not seem recommenable as a general dietary fat source. Since functional consideration in food processing seem not always correspond with nutritional perspectives, the nutritional quality of specifically designed rapeseed oils needs to be thoroughly evaluated including all physiological aspects.

References

European Atherosclerosis Society EAS, 1992: Prevention of coronary heart disease: Scientific background and new clinical guidelines. Recommendations of the European Atherosclerosis Society prepared by the International Task Force for Prevention of Coronary Heart Disease. Nutr. Metab. Cardiovasc. Dis. 2, 113-156

FAO Report 57, 1994: Fats and oils in human nutrition.

Fernandez, M.L., Lin, L.C.K., McNamara, D.J., 1992: Regulation of guinea pig plasma low density lipoprotein kinetics by dietary fat saturation. J. Lipid Res. 33, 97-109

Fernandez, M.L., Soscia, A.E., Sun, G.S., Tosca, M., McNamara, D.J., McDonald, B.E., 1996: Olive oil and rapessed oil differ in their effect on plasma low-density lipoprotein metabolism in the guinea pig. Br. J. Nutr. 76, 869-880

Gardner, C.D., Kraemer, H.C., 1995: Monounsaturated versus polyunsaturated dietary fat and serum lipids. A meta-analysis. Arterioscler. Thromb. Vasc. Biol. 15, 1917-1927

Gustafsson, I.-B., Vessby, B., Öhrvall, M., Nydahl, M., 1994: A diet rich in monounsaturated rapeseed oil reduces the lipoprotein cholesterol concentration and increases the relative content of n-3 fatty acids in serum in hyperlipidemic subjects. Am. J. Clin. Nutr. 59, 667-674.

Hegsted, D.M., McGandy, R.B., Myers, M.L., Stare, F.L., 1965: Dietary fat and serum lipids: an evaluation of the experimental data. Am. J. Clin. Nutr. 17, 281-295

Katan, M.B., Zock, P.L., Mensink, R.P., 1994: Effects of fats and fatty acids on blood lipids in humans: an overview. Am. J. Clin. Nutr. 60 (suppl.), 1017S-1022S

Keys, A., Anderson, J.T, Grande, F. 1965: Serum cholesterol response to changes in the diet. IV. Particular saturated fatty acids in the diet. Metabolism 14, 776-787

Mattson, F.H., Grundy, S.M., 1985: Comparison of effects of dietary saturated, monounsaturated, and polyunsaturated fatty acids on plasma lipids and lipoproteins in man. J. Lipid. Res. 26, 194-202

McDonald, B.E., Gerrald J.M., Bruce, V.M., Corner, E.J.,1989: Comparison of effect of canola oil and sunflower oil on plasma lipids and lipoproteins and on vivo thromboxane A_2 and prostacyclin production in healthy young men. Am. J. Clin. Nutr. 50, 1382-1388

Mensink, R.P., Katan, M.B., 1989: Effect of a diet enriched with monounsaturated or polyunsaturated fatty acids on levels of low-density and high-density lipoprotein cholesterol in healthy women and men. N. Eng. J. Med. 321, 436-441

Nydahl, M.C., Gustafsson, I.B., Vessby, B., 1994: Lipid-lowering diets enriched with monounsaturated or polyunsaturated fatty acids but low in saturated fatty acids have similar effects on serum lipid concentrations in hyperlipidemic patients. Am. J. Clin. Nutr. 59, 115-122

Trautwein, E.A., Kunath-Rau, A., Dietrich J., Drusch, S. Erbersdobler, H.F., 1997: Effect of dietary fats rich in lauric, myristic, palmitic, oleic or linoleic acid on plasma, hepatic and biliary lipids in cholesterol fed hamsters. Br. J. Nutr. 77,

Valsta, L.M., Jauhiainen, M., Aro, A., Katan, M.B., Mutanen, M., 1992: Effects of a monounsaturated rapeseed oil and polyunsaturated sunflower oil diet on lipoprotein in humans. Arteriosclerosis and Thromb. 12, 50-57

Valsta, L.M., Jauhiainen, M., Aro, A., Salminen, I., Mutanen, M., 1995: The effects on serum lipoprotein levels of two monounsaturated fat rich diets differing in there linoleic and α-linolenic acid contents. Nutr. Metab. Cardiovasc. Dis. 5, 129-140

Wardlaw, G.M., Snook, J.T., Lin, M.Ch., Puangco, M.A., Kwon, J.S.,.1991: Serum lipid and apolipoprotein concentrations in healthy men on diets enriched in either canola oil or safflower oil. Am. J. Clin. Nutr. 54, 104-110