Rapeseed for human nutrition – present knowledge and future options

Christian A. Barth

Institut für Ernährungswissenschaft, Universität Potsdam, D 14558 Nuthetal, Germany. barth@dife.de

Brassica species are now the second largest oilseed crop worldwide yielding an edible oil with remarkable nutritional attributes.

Fatty Acids. Nutrition strategy for prevention of cardio-vascular diease aims at reducing intake of saturated and raising consumption of n-3 polyunsaturated and mono-unsaturated fatty acids. At the same time moderation of n-6 polyunsaturated fatty acids is advised. These 4 targets can be reached by raising the consumption of rape oil.

Rape oil has an exceptionally low amount of saturated fatty acids and a comparatively low concentration of n-6 fatty acids (linoleic around 20 %). (Table 1).

Table 1. Fatty acid content (g/ 100g total fatty acids). of edble vegetable fats and oils (Gurr, 1992)

Commodity	Saturated Fatty Acids	Monounsaturated Fatty Acids	Linoleic Acid (N-6)	Linolenic Acid (N-3)
Coconut	90	7	2	0
Corn	17	30	50	2
Olive	14	72	11	1
Palm	47	43	8	trace
Rape (low erucic)	5	54	23	10
Safflower (high linoleic)	9	15	73	1
Soyabean	14	25	52	7
Sunflower	12	33	52	trace

Simultaneously, the ratio of dietary n-6 / n-3 polyunsaturated fatty acids from presently 15: 1 in the Western diet can be lowered towards 5:1 as recommended by international recommendations for a healthy diet (German Nutrition Society, 2002; Krauss *et al.*, 2000). This is due to the comparatively low ratio of n-6/ n-3 in rape oil (Table 2).

Table 2. Comparison of edible oils: n-6 and n-3 fatty acids in absolute and relative contents.

Commodity	n- 3 Fatty acids g / 100g	Ratio n-6 / n-3
Marine Fish (Herring)	3	0.1
Nuts (Walnut)	3	10
Rape Oil	11	1.9
Linseed Oil	57	0.28
Soy Oil	7	7.7
Olive Oil	< 1	13.2
Sun Flower Oil	< 1	> 70

Considering these data it is no surprise that diverse beneficial metabolic effects of rapeseed oil have been reported. In controlled studies with healthy adult volunteers this oil provoked favourable effects on level and composition of serum lipoproteins (Kratz *et al.*, 2002). First, the serum lipoprotein profile changes were as favourably as those caused by olive or sunflower oil. Secondly, the Low Density Lipoprotein (LDL) particles were particularly protected from oxidation presumably by the high content of the monounsaturated fatty acid, oleic acid (18:1), in the lipoprotein following rapeseed oil consumption. Third, a rise of eicosapentanoic acid (20:5, n-3) in these particles (Kratz et al., 2002) proved the elongation of α- linolenic acid to this long-chain n-3 fatty acid which has been shown repeatedly to be protective what concerns cardio-vascular events (Mozzafarian, 2006).

Moreover, most of the prospective epidemiological studies suggest that the preeminent n-3 polyunsaturated fatty acid in rapeseed oil, namely α-linolenic acid, reduces the incidence of coronary heart disease (Brouwer IA, 2004). In an intervention study with patients after myocardial infarction in which the n-6 / n-3 ratio of dietary fatty acids (linoleic vs linolenic acid) was about 4 : 1, a significant reduction in the reinfarction rate has been achieved (de Lorgeril *et al.*, 1999). In summary, a multitude of data strongly suggest a cardioprotective effect of rapeseed oil by its dominant n-3 polyunsaturated fatty acid α-linolenic acid (18:3, n-3) which warrants to be corroborated by further confirmatory evidence (Barth, 2006; Geleijnse, 2006; Zock, 2006).

Safety. Whereas n-3 fatty acid containing food, as e. g. marine fish, has generally been reported to lower the risk for cancer some earlier studies observed a rise of risk for prostate cancer. These latter studies are inconsistent, because two prospective and four case-control studies observed no association between dietary, serum, adipose, or prostate tissue α-linolenic acid levels and prostate cancer risk, whereas, in contrast, three prospective and five case-control studies reported a statistically significant or non-significant 2-4-fold increased risk of prostate cancer among men with high α-linolenic acid exposure determined by dietary or blood assessment. All these studies are merely epidemiological evidence, whereas *in vitro* and metabolic findings are lacking (Leitzmann, 2006; Leitzmann, 2004).The lack of consistency may be caused methodologically as exposure to α-linolenic acid can hardly or only imprecisely determined in epidemiological studies (Leitzmann, 2006). In summary, further evidence in men is needed to resolve the relation of n-3 fatty acids, α-linolenic acid in particular, and risk of prostate cancer (Leitzmann, 2006). To summarize, there is no consistent set of data from epidemiological, metabolic and biochemical research substantiating a risk of rape oil consumption at the present time. Further such research is needed. Another topic for future research is the definition of safe limits of different procedures applied in industrial usage of rapeseed oil, particularly heating procedures like deep frying and others with the aim to prevent or minimize formation of potentially toxic products (Warner, 1999).

Rapeseed Protein. Animal nutritionists are well aware of the nutritional value of rapeseed protein. It is extensively used in monogastric, poultry and ruminant feeds. For example, satisfying weight gains of more than 800 g/day can be achieved in pig production if 10 % of rapeseed meal with less than 10 mmol glucosinolates/kg meal is fed (Weiss, 2006).Nutritional evaluation of rapeseed meal by earlier investigators resulted in somewhat lower but considerable weight gains in several animal species if compared to soy concentrate (Fig.1). This is based on the high biological value of rapeseed protein caused by a favourable amino acid profile (O´Mara, 1997). The somewhat lower weight gain by rapeseed meal as compared to soy concentrate is caused by a lower true protein digestibility (78.9% vs 90.4%) (Drouliscos, 1969) and bioavailability of the limiting amino acid lysine. The prececal digestibility of rapeseed meal lysine as measured in the pig amounts to 75 % as compared to 89 % of soy concentrate lysine (Weiss, 2006). Also the PDCAAS was reported to be significantly lower (Rozan, 1997). This can be explained by the comparatively high concentration of 14-16 % of crude fiber (per dry matter) in rapeseed meal impeding protein digestibility. So, whereas the content of 5,9 g lysine per 16 g N of rapeseed protein is considerable and sufficient to meet the nutritional requirements this satisfying biological value is compromised by the accompanying fiber. This leads to conclude that attempts to exploit rapeseed protein for human nutrition have to remove substances impeding digestibility either by breeding or food technology (see below).

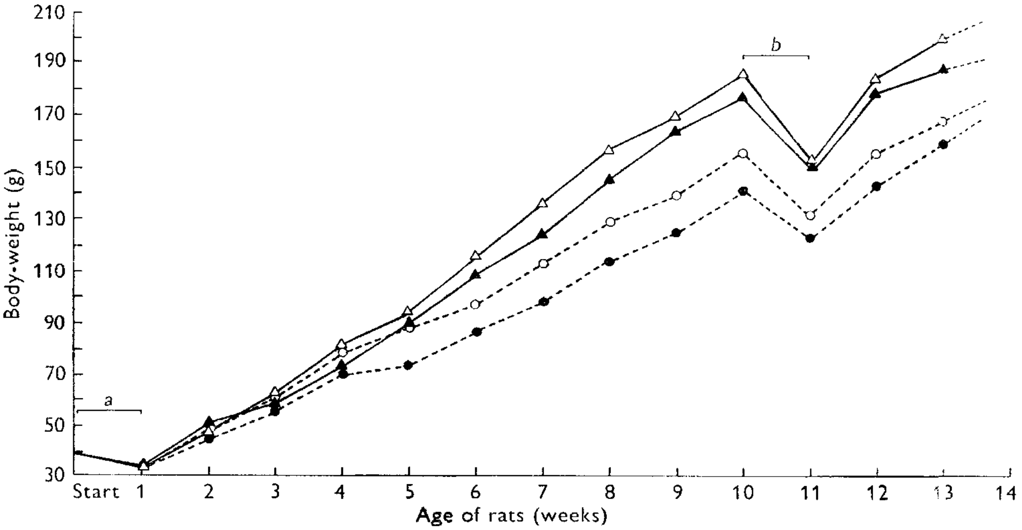

Fig. 1. Body-weight (g) gains of rats from weaning to maturity. The periods of protein-free feeding are indicated by *a* and *b* on the curve. △—△, SM diet; ▲—▲, CS diet; ○—○, RM(S) diet; ●—●, RM(PS) diet.

Fig. 1: RM(S) = rapeseed meal. SM = Soy concentrate.

Drouliscos (1969)

Minor components. Rapeseed meal contains water-soluble vitamins, as thiamine (0,82 mg/100 g dry wt), riboflavin (0,33 mg/100g), niacin (8 mg/100g), pyridoxine (1,8 mg/100g) and pantothenate (0,48 mg/100g) (Mansour; 1993). Tocopherols range between 600-700 mg/kg rapeseed oil, γ- and α- forms contributing 64 and 35 %, respectively, and the δ-form less than 1 % (Goffman, 2000). Rapesseed oil has the highest amount of total antioxidants, stability (against oxidative damage), and total radical-trapping antioxidant potential among other oils (sunflower varieties and grapeseed) (Ciz, 2002) A number of more polar phenolics, like sinapinic acid and its derivatives contribute to this activity (Vuorela, 2005).

Technology. As mentioned the prerequisite for rapeseed protein use in human nutrition is the removal of antinutrients, as glucosinolates, tannins and fiber among others. Several technological attempts are being pursued to reach preparations with satisfying solubility and sensoric quality for food purposes (Anonymous, 2006; Klockemann, 1997; Leckband, 2002).

Breeding. A major breeding target is the creation of yellow-seeded varieties with a lower amount of substances as sinapine, cellulose, tannins or lignine in order to raise protein digestibility and sensoric acceptance. A health-related target is the introduction of " fish" very long-chain n-3 polyunsaturated fatty acids (20:5, n-3 and 22:6,.n-3) (Leckband, 2002) for populations living in areas distant from the coast. Moreover, plant production of these nutritionally valuable fatty acids will be an important alternaive to the insufficient if not shrinking marine resources for future world nutrition (Pimentel, 1996).

Summary and conclusions. Rapeseed oil is a nutritionally highly valuable complement of human nutrition recommended unanimously by numerous national and international authorities because of its low content of saturated and high content of n-3 polyunsaturated and monounsaturated fatty acids. Recent observations suggesting a possible relation with prostate disease and risks by heating this commodity by industrial processes or cooking should be pursued and scrutinized in future research. It is worthwile to elaborate further by nutrition research the health attributes of minor compounds (vitamins, polyphenols, plant sterols among others) of rapeseed. The outstanding antioxidative potential of these constituents harbors a promising perspective for human health. Rapeseed protein is a biologically valuable plant protein with an optimal perspective for human nutrition provided antinutrients impeding protein digestibility will be removed by breeding or food technology. Plant breeding offers numerous options for future usage of rapeseed. Among these is the introduction of very-long-chain n-3 polyunsaturated fatty acids of the seafish type into rapeseed oil particularly attractive for human health.

References

Anonymous. (2006). Burcon nutrascience corp.www.burcon.net; accessed 28. 11. 2006

Barth, C. Erbersdobler., HF. (2006). Cardiovascular health and safety of rapeseed oil in human nutrition. *Akt. Ernaehr Med, 31*, 2111-2117.

Brouwer IA, Katan. M., Zock PL. (2004). Dietary alpha-linolenic acid is associated with reduced risk of fatal coronary heart disease, but increased prostate cancer risk: A meta-analysis. *J Nutr, 134,919-922*

Ciz, M., Gorinstein, S, Lojek, A, Martin-Belloso, O, Leontowich, H Trakhtenberg, S. (2002). Comparative antioxidative properties of selected seed oils. *Free Radical Research, 36 S1*, 64-65.

de Lorgeril, M., Salen, P., Martin, J. L., Monjaud, I., Delaye, J., & Mamelle, N. (1999). Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction: Final report of the Lyon diet heart study. *Circulation, 99*(6), 779-785.

Drouliscos, N., Bowland,JP. (1969). Biological evaluation of rape-seed meal in rats. *Br J Nutr, 23*, 113-118.

Geleijnse, J. (2006). Health effects of alpha-linolenic acid and experimental design of the alpha omega trial (abstr.). *Akt Eraehr Med, 31*, 214-215.

German, S. N. (2002). *Reference values for nutrient intake*. Frankfurt/Main, Germany: Umschau Braus.

Goffman; FD, Moeller., C, &. (2000). Changes in tocopherol and plastochromanol-8 contents in seeds
and oil of oilseed rape (brassica napus l.) during storage as
influenced by temperature and air oxygen. *J Agric Food Chem, 48*, 1605-1609.

Gurr, M. I. (1992). Role of fats in food and nutrition. Elsevier Applied Science Publishers, London.

Klockemann, D., Toledo, R, Sims; KA. (1997). Isolation and characterization of defatted canola meal protein. *J Agric Food Chem, 45*(10), 3867-3870.

Kratz, M., Cullen, P., Kannenberg, F., Kassner, A., Fobker, M., Abuja, P. M., et al. (2002). Effects of dietary fatty acids on the composition and oxidizability of low-density lipoprotein. *Eur J Clin Nutr, 56*(1), 72-81.

Krauss, R. M., Eckel, R. H., Howard, B., Appel, L. J., Daniels, S. R., Deckelbaum, R. J., et al. (2000). AHA dietary guidelines: Revision 2000: A statement for healthcare professionals from the nutrition committee of the american heart association. *Circulation, 102*(18), 2284-2299.

Leckband, G., Frauen, M, Friedt,W. (2002). Napus 2000. Rapeseed (brassica napus) breeeding for improved human nutrition. *Food Res Int, 35*(2-3), 273-278.

Leitzmann, M. (2006). N-3 fatty acids and risk of prostate cancer (abstr.). *Akt Eraehr Med, 31*, 215.

Leitzmann MF, S. M., Michaud DS, Augustsson K, Colditz GC, Willett WC, Giovannucci EL. (2004). Dietary intake of n-3 and n-6 fatty acids and the risk of prostate cancer. *Am J Clin Nutr., 80*, 204-216.

Mansour; EH, D., E, Lugasi, A, Gaal, O Barna, E, Gergeley,A. (1993). Effect of processing on the antinutritive factors and nutritive value of rapeseed products. *Food Chemistry, 47*, 247-252.

Mozzafarian, D. R., Rimm, EB. (2006). Fish intake, contaminants, and huiman health. *JAMA, 296*, 1885-1899.

O´Mara, F., Murphy, JJ, Rath, M. (1997). The amino acid composition of protein feedstuffs before and after ruminal incubation and after subsequent passage through the intestines of dairy cows. *J Anim Sci, 75*, 1941-1949.

Pimentel, D., Shanks, RE, Rylander, JC. (1996). *Energy use in fish and aquacultural production*. In: Food, Energy, and Society. Pimentel,D and Pimentel, M ed. Niwot,Co: University Press of Colorado.

Rozan, P., Lamghari, R, Linder, M, Villaume, C, Fanni, J, Parmentier, M, Mejean, L. (1997). In vivo and in vitro digestibility of soybean, lupine, and rapeseed meal proteins after various technological processes. *J Agric Food Chem, 45*, 1762-1769.

Vuorela, S., Kreander, K, Karonen, M, Nieminen, R, Hämäläinen, M, Galkin, A, Laitinen, L, Salminen, J, Moilanen, E, Pihlaja, K, Vuorela, H, Vuorela, P, Heinonen, M. (2005). Preclinical evaluation of rapeseed, raspberry, and pine bark phenolics for health related effects. *J Agric Food Chem, 53*, 5922-5931.

Warner, K. (1999). Impact of high-temperature food processing on fats and oils. *Adv Exp Med Biol, 459*, 67-77.

Weiss, J. Schoene., F. (2006). Rapsextraktionsschrot in der Schweinefütterung. *Praxisinformation*. UFOP. www,ufop.de; accessed 28. 11. 2006

Zock, P. (2006). An overview on alpha-linolenic acid and cardiovascular disease (abstr.). *Akt. Eraehr Med, 31*, 214.