

THERE IS NO DETERIORATION OF **CLEAR HEMP COOKING AND SALAD OIL™** UNLESS TEMPERATURES ARE WELL ABOVE 250 C (482F) FOR MUCH MORE THAN ONE-HALF HOUR OR WELL ABOVE 200 C (392 F) FOR LONGER THAN 16 HOURS.

H. Molleken : *Trans*-fatty acids in heated hemp seed oil

Bergische Universitat, Physiologische Chemie der Pflanzen, Gauss-Str. 20, 42119 Wuppertal, Germany

Molleken, H. 1998 *Trans*-fatty acids in heated hemp seed oil. *Journal of the International Hemp Association* 5(1): 21-23. Prompted by the frequently discussed question of whether *trans*-fatty acids are formed when hemp oil is used for cooking, we have analysed hemp oil and several other oils for their content after exposing them to various stress conditions. The results demonstrate that high temperatures do not change the configuration of the fatty acids.

Introduction

Fats and oils have been of interest to biochemists, nutritionists and health professionals for many years, and one of the points of discussion is the presence of *trans*-fatty acids (*t*-FAs). The double bonds of essential fatty acids (FAs) are confined to certain positions on the aliphatic chain and are all of the *cis* configuration. Relatively large amounts of *t*-FAs have been found only in a few plant species, mainly in the seeds and leaves. The highly polyunsaturated FA 18:2 (10 *trans*, 12 *trans*), for example, occurs to the extent of 5-10% in the Mexican bush *Chilopsis linearis*, and there is as much as 40% of FA 18:3 (9 *trans*, 11 *trans*, 13 *trans*) in the triglycerides of various *Catalpa* specie (Belitz & Grosch 1994, Sommerfeld 1983, Steinhardt & Pfalzgraf 1994, Steinhardt 1996). These are exceptions however, as *t*-FAs normally occur to a minimal extent in plants, if at all.

In contrast, *t*-FAs are widely found in animal fats. They largely originate from their diet, although in marsupials and ruminants *t*-FAs are synthesized in the rumen or stomach by microbial hydrogenation of the polyunsaturated FAs from plant food. Thus some *t*-FAs in the human diet are traced to milk and meat. In human metabolism, they are also formed during degradation of unsaturated FAs, though the *cis*-configuration is of physiological importance. Polyunsaturated FAs, for example, loosen the packing of the phospholipids within the hydrophobic zone of biological membranes.

In the human diet, *t*-FAs arise mainly from isomerisation of the natural *cis* double bonds of vegetable oils during their industrial hydrogenation to margarine and vegetable shortenings. The change in the configuration of the double bond means that the acyl chain more closely resembles that of saturated FAs. The accompanying hydrogenation of some of the double bonds also means, of course, that an important property of the food oils – the high content of polyunsaturated FAs – is sacrificed in favor of increased stability and a higher melting point (Pelitz and Grosch 1994, Steinhardt 1996).

Many foods made with milk or hydrogenated oils (for example: deep-fry, chips, butter, cheese, margarine) contain *t*-FAs. Normally, they cannot be found in products made from non-hydrogenated vegetable oils. Table 1 compares the content of *t*-FAs in various foods. Whereas products of milk and hydrogenated oils have a high content of *t*-

FAs , the vegetable oils and their products *e.g.*, mayonnaise, have no more than 0.4% and often have none.

The physiological effects of these hydrogenated dietary fats, and especially the influence of *t*-FAs , on human metabolism have therefore been of great scientific interest for a long time . For example, *t*-FAs have been connected with arteriosclerosis and cancer, but up to now, these investigations are incomplete and controversial (Ascherio *et al.* 1997, *Arzte Zeitung* 1994, Christiansen *et al.* 1997, Kohlmeier *et al.* 1997, Katan *et al.* 1994, Koga *et al.* 1997, Lichtenstein 1993, VDD-Mitteilungen 1994, Shapiro *et al.* 1997, Wolfram 1994).

The presence of *t*-FAs also becomes a matter for discussion when vegetable oils, such as hemp seed oil, are used for cooking or frying (Huppertz *et al.* 1997). We have therefore heated hemp oil at several temperatures and analysed its deterioration and isomerisation.

Table 1. *trans*-FAs in various food products.

Food Product	<i>t</i> -Fas in %	approx. mean % <i>t</i> -FA's; % FA's
margarine	0.0-10.6	4.5
chocolate spreads	0.7-11.1	5.5
butter	3.7-5.2	4.7
cheese	1.8-5.4	3.6
diet margarine	0.0-0.4	<0.2
vegetarian spreads	0.1-0.4	<0.2

(cf. Demmelmair *et al.* 1996, Fernandez San Juan 1996, Gertz 1996, Molleken 1996, Ulberth and Henninger 1994, VDD Mitteilungen 1994)

Materials and Methods

Various samples of hemp seed oil were held in an electric heater: (1) for 30 min. at a constant temperature between 170 C and 350 C and (2) for 16 hours between 200 C and 220 C. A 10-ml sample was then homogenized with 1 ml methylene chloride (CH₂Cl₂). 100 ml trimethylsulfonium hydroxide (TMSH) was added for quantitative hydrolysis of the triglycerides (Molleken and Theimer 1997a, b) and conversion of the resulting FAs to FA methyl esters (FAMES). The resulting FAMES were analyzed on a HP 5890 gas chromatograph equipped with an FID detector, using compound standards from Sigma (Deisenhofen, Germany) for comparison.

Table 2. FAME from hemp oil treated under different temperature conditions*

	FAMES Fatty Acid Type	native (not heated)	338 F	428 F	482 F	662 F
			170 C 30 min. %	220 C 30 min. %	250 C 30 min. %	350 C 30 min. %
16 carbon, saturated	C16:0	8.94	8.86	8.41	9.21	14.92
18 carbon, saturated	C18:0	3.52	3.45	3.47	3.51	12.25
18 carbon, mono-unsaturated, cis.fat	C18:1, 9c	11.00	10.75	10.95	11.07	22.53
18 carbon, mono-unsaturated, trans.fat	(C18:1, 9t)					2.95
18 carbon, mono-unsaturated cis. fat	C18:1, 11c	1.00	1.01	1.02	1.08	
Omega 6, cis. fat	C18:2, 9, 12c	53.64	53.54	53.74	53.39	20.87
Omega 6, trans. fat	(C18:2, 9, 12t)					10.98
GLA, cis. fat	C18:3, 6, 9, 12c	2.15	2.10	2.10	2.03	
Omega 3, cis. fat	C18:3, 9, 12, 15c	17.44	17.92	17.87	17.26	2.33
Omega 3, trans. fat	(C18:3, 9, 12, 15t)					3.17
18 carbon, 4 unsaturated bonds	C18:4, 6, 9, 12, 15c	0.79	0.79	0.86	0.75	
20 carbon, saturated	C20:0	0.94	1.06	1.03	1.14	
20 carbon, mono-unsaturated, cis. fat	C20:1, 11c	0.58	0.52	0.55	0.56	

*The data represent the mean of about three analyses. The standard deviation of all data lies between 0.00 and 0.19.

Important: There is no increase in saturated fats, no decrease in Omega fats, no formation of trans fats until oil has been heated to 662F for 30min.

Table 3. FAME from hemp oil treated under different temperature conditions*

	FAMES Fatty Acid Type	native (not heated)	392F	428F
			200 C 16 hrs. %	220 C 16 hrs. %
16 carbon, saturated	C16:0	8.94	8.56	12.78
18 carbon, saturated	C18:0	3.52	3.40	4.95
18 carbon, mono-unsaturated, cis.fat	C18:1, 9c	11.00	11.17	15.45
18 carbon, mono-unsaturated, trans.fat	(C18:1, 9t)		0.85	n.d.
18 carbon, mono-unsaturated cis. fat	C18:1, 11c	1.00	1.10	1.43
Omega 6, cis. fat	C18:2, 9, 12c	53.64	53.09	49.67
Omega 6, trans. fat	(C18:2, 9, 12t)		0.82	0.69
GLA, cis. fat	C18:3, 6, 9, 12c	2.15	2.14	1.61
Omega 3, cis. fat	C18:3, 9, 12, 15c	17.44	17.46	10.15
Omega 3, trans. fat	(C18:3, 9, 12, 15t)		n.d.	1.00
20 carbon, saturated	C20:0	0.94	0.90	1.58
20 carbon, mono-unsaturated, cis. fat	C20:1, 11c	0.58	0.46	0.69

The data represent the mean of about three analyses. The standard deviation of all data lies between 0.00 and 0.28. n.d.= not detected

Important: There is no significant deterioration after 16 hrs. heating @ 392F but there is serious loss of Omega 3 fats after 16 hrs. heating @428F.

Results

Table 2 compares the influence of various temperatures on the *t*-FA content of hemp seed oil. It is clear that cooking temperatures of about 170-250 C do not lead to an increase of the *t*-FAs. Similar investigations with other hemp seed oils underscore these results. Only two oils had a *t*-FA content of 0.85% after being heated at 220 C for half an hour (Molleken and Melchior 1998). In contrast, a temperature of 350 C deteriorates the hemp oil, and leads to the formation of significant amounts of *t*-FAs.

This fact is confirmed by the results in Table 3. Some *t*-FAs can be detected in hemp oil that is held at 200 to 220 C for a long period (16 hours). Thus, isomerisation does take place under prolonged moderate stress, so that *t*-FAs are formed and the amounts of the unsaturated FAs decrease.

Discussion and Conclusion

Both experiments demonstrate that isomerisation to *t*-FAs does not occur when native hemp oil is used under normal cooking conditions, though the contrary seems to be generally accepted (Huppertz *et al.* 1997). Experiments with various vegetable oils (for example from sunflower, safflower, soy bean or walnut) give similar results (Molleken and Melchior 1998). The comparison of Table 1 and Table 2 also supports this conclusion. It is obvious that hydrogenated vegetable oils like margarine and deep-fry fats contain *t*-FAs in higher amounts than heated hemp oil.

This does not mean that the polyunsaturated FAs of hemp oils are stable towards all negative influences. Under especially stressful conditions they do change their configuration or get destroyed, and then *t*-FAs, hydroxy FA's, hydroperoxides, aldehydes and ketones can be formed (Molleken and Melchior 1998).

Heated native hemp oils are quite stable under high-temperature conditions. Temperatures of 170-250 C do not stress this oil, so that high concentrations of *t*-FAs are scarcely formed. Presumably antioxidants, such as tocopherols, stabilize the oil, since hemp oils contain enough *gamma*-tocopherol to have a strong antioxidant effect (Belitz and Grosh 1994, Gordon and Kourimska 1994, Molleken and Andersen 1998, Przybylski *et al.* 1997). Further investigations show that the influence of temperature on various vegetable oils leads to degradation of the tocopherols (Molleken & Melchior 1998).

While as much as 6-10 g of *t*-FAs per person per day is thought not to affect health adversely (Arzte Zeitung 1994, Wolfram 1994), the current mean human uptake though normal nutrition (milk, cheese, margarine and deep-fried products, cf. Table 1) has been estimated at only 3-4 g per day (Gertz 1996). It seems reasonable, nevertheless, to keep the amounts of *t*-FAs in the diet to a minimum for general health purposes, and in accordance with this, many people, including scientists, recommend: "Use high-quality vegetable oil for frying, deep-frying and salads" (Arzte Zeitung 1994, Wolfram 1994). Hemp oil fulfills this requirement, since like other vegetable oils, as we show here, it does not form significant amounts of *t*-FAs on being heated at usual cooking temperatures.

References On Request
