Report on Cod Liver Oil:
Testing the Safety and Vitamin Content of our Number One Superfood

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Cod liver oil serves an important function in modern diets since it provides a convenient source of vitamins A and D. When Dr. Weston A. Price studied so-called primitive peoples, he found that they consumed large amounts of fat-soluble vitamins A and D (as well as vitamin K_2, which he called the X Factor) from foods such as pastured butter, egg yolks, organ meats, shellfish, fatty fish and animal fats—as well as from foods that modern people don't normally eat, such as intestines, brain, lungs, thymus, fish liver, fish heads, fish eggs and fat from various game animals. Since it is difficult for modern people to obtain and eat these foods, Dr. Price often recommended cod liver oil.

But Dr. Price was concerned about problems with cod liver oil. In his pioneering work, *Nutrition and Physical Degeneration*, he clearly states that cod liver oil is beneficial in low doses but toxic at high doses. One explanation for this observation is the fact that cod liver oil contains high levels of chemically fragile omega-3 fatty acids, namely EPA and DHA. Even when these fatty acids are not oxidized, an excess can potentially give rise to a number of health issues..

Like all modern foods, most cod liver oil today is subject to processing; in the case of cod liver oil, this processing generally applies heat from steaming, boiling or distillation.[1] These treatments could damage the omega-3 fatty acids in cod liver oil and remove natural vitamins, especially vitamin D. For that reason, the Weston A. Price Foundation has tended to recommend brands of cod liver oil that are extracted at low temperatures, especially through a process of fermenting the livers. The fermented cod liver oil is also reported to have higher levels of natural A and D than found in other brands.

RANCIDITY CONCERNS

In 2015, Dr. Kaayla Daniel released a report claiming that fermented cod liver oil is rancid and dangerous, and that the dark color of the oil is potentially a sign of rancidity.[2]

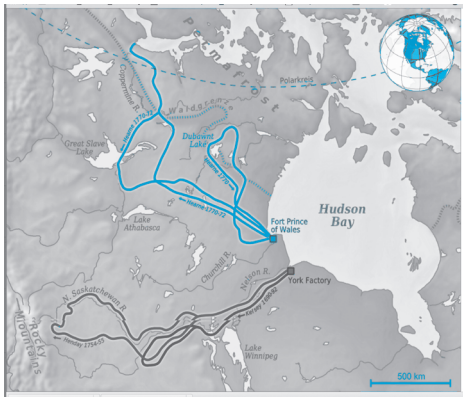
Most laboratories evaluate rancidity with four tests: PV or peroxide value; PA or anisidine value; TBA for thiobarbituric acid; and the TBARS test (for Thiobarbituric Acid-Reactive Substances), a more involved version of the TBA test. Daniel noted that the fermented cod liver oil had acceptably low levels of PV, PA and TBA, but high levels of TBARS.

Experts consider these tests as providing only approximate markers of rancidity, obtained with equipment that is relatively inexpensive and widely available.[3]

A newer and more advanced technique, which uses nuclear magnetic resonance (NMR), can accurately pinpoint a range of peroxides and aldehydes. The testing equipment is expensive and only used in a small number of research laboratories. Aldehydes are small, highly reactive breakdown products of unsaturated fatty acids; they include acrolein and 4-hydroxy-trans-2-nonenal (HNE) (see page 32).

An expert in such NMR testing is Prof. Martin Grootveld, BSc, PhD, FIBMS, CBiol, FSB, FRSC. Highly qualified, Grootveld is a professor at Leicester School of Pharmacy, Faculty of Health and Life Sciences, De Montfort University, Leicester, UK. He is a Fellow of the Royal Statistical Society, professor of Bioanalytical Chemistry and Chemical Pathology, chair at the Faculty of Health and Life Sciences

NATIVE AMERICAN DIETS



Samuel Hearne (1745-1792) was the first European explorer to travel across northern Canada to the Arctic Ocean. He provides a fascinating look at Native American foodways in his diary, *The Journeys of Samuel Hearne,* published 1768.

He writes: "On the twenty-second of July, we met several strangers, whom we joined in pursuit of the caribou, which were at this time so plentiful that we got everyday a sufficient number for our support, and indeed too frequently killed several merely for the tongues, marrow and fat. . . . The most remarkable dish among them, as well as all the other tribes of Indians in those parts, both Chipewyan and Cree, is blood mixed with the half-digested food which is found in the caribou's stomach, and boiled up with a sufficient quantity of water to make it of the consistence of pease-pottage. Some fat and scraps of tender flesh are also shred small and boiled with it. To render this dish more palatable, they have a method of mixing the blood with the contents of the stomach in the paunch itself, and hanging it up in the heat and smoke of the fire for several days; which puts the whole mass into a state of fermentation, which gives it such an agreeable acid taste, that were it not for prejudice, it might be eaten by those who have the nicest palates."

The Indians preferred fat and organ meats to muscle meats. "Of all the dishes cooked by the Indians, a *beeatee*, as it is called in their language, is certainly the most delicious that can be prepared from caribou only, without any other ingredient. It is a kind of haggis, made with the blood, a good quantity of fat shred small, some of the tenderest of the flesh, together with the heart and lungs cut, or more commonly torn into small shivers; all of which is put into the stomach and toasted by being suspended before the fire on a string. . . . it is certainly a most delicious morsel, even without pepper, salt or any other seasoning." Indeed, traditional peoples throughout the world have consumed a type of food similar to haggis—perishable offal quickly cooked inside an animal's stomach, all conveniently available after a hunt—from ancient times. Modern haggis, the traditional dish of Scotland, contains sheep's pluck (heart, liver and lungs); minced with onion, oatmeal, suet (fat) and salt, mixed with stock, traditionally encased in the animal's stomach (pictured left).

Such dishes are exceedingly nutrient dense, providing fat soluble vitamins A, D and probably also K_2 in abundance.

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Research Ethics Committee, head of the Medicinal Chemistry Group, Director of Bioanalysis, Pharmaceuticals and Health Doctoral Training Programme (DTP), and member of the editorial boards of *Bio Analytical Techniques* and *International Journal of Medical and Clinical Research*.

Grootveld's group published a paper describing their findings in which they used NMR to detect high levels of toxic aldehydes in restaurant fryer oil and in commercially available PUFA-rich oils subjected to heating according to standard frying practices.[4] They found only low levels when they subjected commercially available olive oil, coconut oil, lard and beef fat to the same heating process.

The aldehydes are advanced products of lipid peroxidation, and they correspond to what would be picked up by the anisidine value (PA) test. However the anisidine test used in most labs is non-specific, whereas the NMR test is very specific. The researchers noted that in animal experiments, the primary lipid peroxidation products in the diet are not absorbed, or absorbed in only very small quantities, but advanced products (aldehydes such as *c,t*-alka-2,4-dienals and *n*-alkanals) are easily absorbed. Thus it appears that it is the harder-to-determine aldehydes that we should be looking for, in order to avoid foods that contain them.

As for the TBARS test, used by Daniel, Grootveld describes it as "analytical garbage." He considers it completely unreliable, serving little or no value for the estimation of rancidity. The test requires heating the samples for periods of about fifteen minutes. Heating for the test alone causes the breakdown of polyunsaturated fatty acids. According to Grootveld, "All results derived from this heat-dependent test system represent nothing more than artifactual data. The only way to avoid this artefactual peroxidation is to maintain samples at ambient (room) temperature and allow the monitored colouration to develop slowly for a sufficiently long period of time. Even then, the assay remains unspecific, since a wide range of aldehydes and further reactive compounds form colored products on reaction with the TBA reagent."[5]

COD LIVER OIL TESTING

When the Weston A. Price Foundation first became aware of concerns about fermented cod liver oil, they sent a sample to Dr. Grootveld's laboratory for testing. The results came back negative: no aldehydes were found. The Foundation then sent another sample along with samples of four other brands of cod liver oil to Dr. Grootveld. These samples were ordered from their respective manufacturers by an independent individual having no association with the Weston A. Price Foundation. Grootveld directed two independent laboratories to perform two sets of analyses—one on opening the bottle, and another two weeks after opening.

AUSTRALIAN ABORIGINES: A PREFERENCE FOR FAT

The fascinating diet of the Australian Aborigines contained many sources of fat-soluble vitamins. They were keen observers of nature and knew when animals were fattest. During periods of abundance, they slaughtered ruthlessly and consumed only the best and fattest parts of the killed game.

Kangaroos were fat when the fern leaf wattle was in flower; opossums were fat when the apple tree was in bloom. (They prized the highly saturated opossum kidney fat, often eating it raw.) Other signs indicated when the carpet snake, kangaroo rat, mussels, oysters, turtles and eels were fat and so at their best as food. Fat from the intestines of marsupials and emus was a favorite; the yellow fat of the goanna was considered a delicacy. The dugong was another source of fat available to natives on the coasts. The Aboriginal peoples prized eggs from reptiles and birds and insects such as wichiti grubs and dugong moths, all rich sources of fat. For the Aborigines, foods lacking fat were "rubbish." Kangaroos not fat enough were rubbish and thrown away—they were not worth carrying back to camp.

A study of the Bardi people in northwestern Australia found that they fished for different species of fish when they had the most fat lining the intestines. (Unlike fish from cold regions, tropical fish have very little fat in their flesh.) This fat was painstakingly removed, melted in a shell or tin can set on the coals and then drunk or used as a dip for the flesh of the fish. The Bardi harvested rock oysters during spring tides; oysters taken at other times were rubbish. An analysis found that the oysters harvested during spring were four times richer in fat. Interestingly, analysis of fat from fish guts, from fish livers, from oysters, and from turtle meat, fat and organ meats, found that the predominant fat was saturated.

SOURCE: Rouja and others. *Fat, Fishing Patterns, and Health Among the Bardi People of North Western Australia*. Lipids 2003 38(4):399-405.

The samples tested represent the five major types of cod liver oil available commercially: molecularly distilled with vitamins added; molecularly distilled without added vitamins; extracted without heat; steam extracted; and extracted without heat through fermentation of the livers. The results of these tests are shown in Figure 1.

The molecularly distilled cod liver oil with added vitamins contained low levels of n-alkanals on opening, with lower levels after two weeks. This brand also contained terpinoids called neral and geranial, which are themselves aldehydes (i.e., non-lipid oxidation-derived aldehydes) derived from a lemon oil flavoring added to the oil.

The highest levels of aldehydes were found in the molecularly distilled cod liver oil without added vitamins. One of the labs found these levels to be considerably lower fourteen days after opening. According to Grootveld, the disappearance of these aldehydes may be attributable to to volatility and evaporation after exposure to air.

Sample three, of unheated cod liver oil, contained low levels of *c,t*-alka-2,4-dienals.

One sample of steam-extracted cod liver oil contained CHPDs—which are precursors to aldehydes—after fourteen days.

Howeverm the fermented cod liver oil contained no detectable levels of aldehydes or CHPDs, even after fourteen days.

HOW DANGEROUS?

The question is, how dangerous are the non-fermented brands of cod liver oil? Is taking a teaspoon of molecularly distilled cod liver oil as risky as eating a piece of Kentucky fried chicken prepared in lard or vegetable oil?

Grootveld's team tested lard and corn oil after pan frying for various lengths of time. The results are shown in Figure 2. Total aldehydes are zero in lard pan heated up to ten minutes and in corn oil pan heated up to five minutes. At longer time intervals, aldehydes climb to levels considerably higher than those found in any type of cod liver oil. Indeed, lard heated for ninety minutes contains ten to one hundred times more total aldehydes than molecularly distilled cod liver oil, while corn oil heated to ninety minutes—typical when preparing large amounts of fried foods—can contain close to two hundred times the levels found in molecularly distilled cod liver oil. Since a fried chicken meal is likely to contain at least two or three tablespoons of lard or corn oil, the danger from a daily teaspoon of cod liver oil is considerably less. Obviously we need much more research on this important topic.

It is interesting to speculate on why the brown fermented cod liver oil is so stable, free from any detectable breakdown products.

Research indicates that the phenolic compounds in olive oil may play a role in preventing deterioration of the fatty acids.[6] Phenols are plant compounds, some of which can give color to an oil—the brown color of fermented cod liver oil is due to the presence of high levels of these types of phenols. Thus, the dark, translucent color of fermented cod liver oil should not be taken as an indication of rancidity, but as a sign that the oil is stable and safe. (By contrast, the dark opaque color of industrial cod liver oil, the dregs of the steaming or distillation process, is likely due to impurities.)

TRANS FATTY ACIDS IN COD LIVER OIL

In her report, Dr. Daniel noted the presence of *trans* fatty acids in

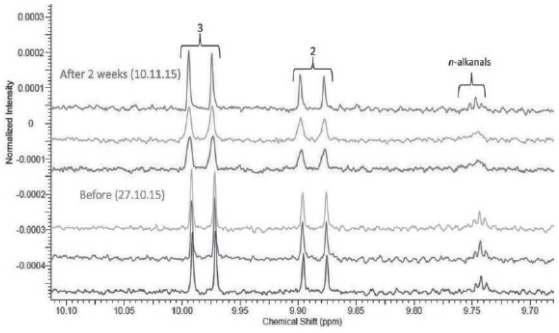
FROM THE SOUTH SEAS

The Maoris of New Zealand consume the Kahawi fish during times of the year when it is fattest—typically stuffed with all the organs except the gall bladder. Photo by Kay Baxter

Fermented shark liver oil from Tahiti. Shark livers are put inside the shark stomach and hung in the trees to ferment. Each liver provides about one liter of fermented oil. Photo by Kay Baxter

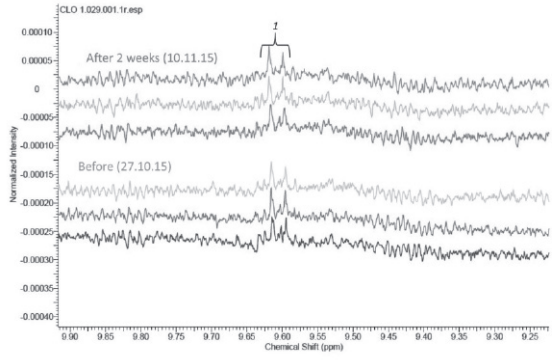
FIGURE 1: RESULTS OF COD LIVER OIL RANCIDITY TESTING ON OPENING AND AT TWO WEEKS

All samples were tested at two different labs. Each value represents the mean of three determinations. Results are given in umole per mole of total fatty acids.



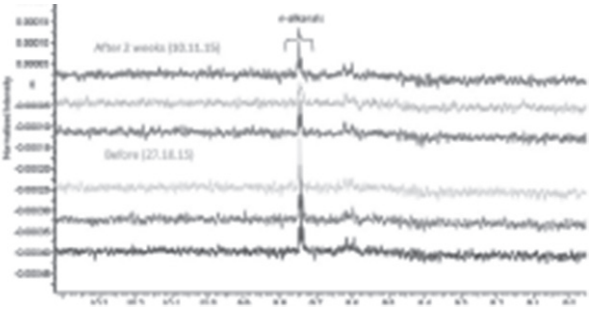
Exposure to Air (14 days)	Site	c,t-alka-2,4-dienals	n-alkanals	neral	geranial	CHPDs
No	Lab 1	nd	63	157	295	nd
No	Lab 2	nd	51			nd
Yes	Lab 1	nd	33	130	279	nd
Yes	Lab 2	nd	22			nd

OIL 1: Molecularly distilled cod liver oil with added vitamins. The two sets of peaks on the left are neral and geranial, aldehydes that are not actually lipid oxidation products, but arise from added lemon oil flavoring material.



Exposure to Air (14 days)	Site	c,t-alka-2,4-dienals	n-alkanals	neral	geranial	CHPDs
No	Lab 1	29	96	nd	nd	nd
No	Lab 2	34	153	nd	nd	nd
Yes	Lab 1	22	17	nd	nd	nd
Yes	Lab 2	39	41	nd	nd	nd

OIL 2: Molecularly distilled cod liver oil with no added vitamins. Significantly lower level of n-alkanals after two weeks found by Lab 2 is probably due to volatility and evaporation during exposure to atmospheric oxygen.



Exposure to Air (14 days)	Site	c,t-alka-2,4-dienals	n-alkanals	neral	geranial	CHPDs
No	Lab 1	74	nd	nd	nd	nd
No	Lab 2	34	nd	nd	nd	nd
Yes	Lab 1	22	nd	nd	nd	nd
Yes	Lab 2	39	nd	nd	nd	nd

OIL 3: Unheated cod liver oil showing n-alkanals on opening and at two weeks.

fermented cod liver oil and speculated that this would indicate an adulteration of the oil with vegetable oils.

However, *trans* fatty acids are a natural component of fish oils; they are manufactured by microorganisms that reside in the fish, including a fungus, *Cladosporium sphaerospermum*, along with several species of bacteria.

Grootveld's lab analyzed all five samples for *trans* fat components and found that all five types contained *trans* fatty acids (see Figure 3). Levels were higher in the fermented cod liver oil as expected, as the bacteria increase production of *trans* fats in the presence of phenols.[7]

Adulteration with vegetable oil is highly unlikely since the fermented cod liver oil shows no signs of oxidation products. The question of whether these marine *trans* fatty acids have health benefits—as do the natural *trans* fats found in the fat of ruminant animals—awaits further research.

VITAMINS IN COD LIVER OIL

WAPF also sent samples of three brands of cod liver oil to two different commercial labs to test for vitamins A, D_2 and D_3: Covance in Wisconsin and UBE laboratory in California. In general, results from UBE were considerably higher than those for Covance. The results are shown in Figure 4.

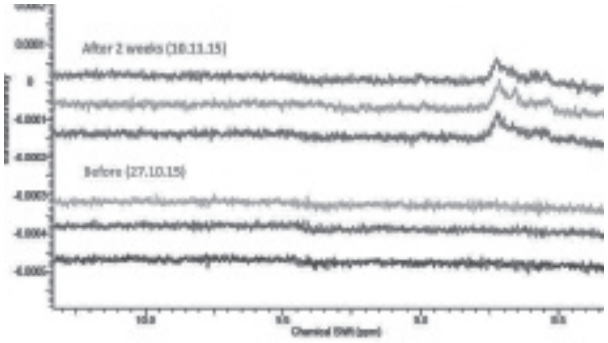
As expected, the molecularly distilled cod liver oil had low levels of vitamin A and no detectable levels of D_3 or D_2, because much of the vitamin content, especially the vitamin D content, is removed during the distillation process.

Vitamin A was higher in the unheated and fermented brands of cod liver oil, with the fermented cod liver oil measuring about 30-40 percent higher than the unheated brand. Total retinol plus palmitate for the fermented cod liver oil was 6080 IU/teaspoon, in the lower range of values found by the manufacturer, which have varied between 5,000 and 12,500 IU/teaspoon.

As for vitamin D, neither lab found appreciable levels of vitamin D_3 in any of the three brands. UBE found 540 IU/teaspoon of a form labeled D_2 in the molecularly distilled cod liver oil, and about triple that amount in the unheated and fermented cod liver oils. Levels indicated as D_2 were similar in the unheated and fermented products. The manufacturer of fermented cod liver oil reports a range of 1,500-5,500 IU/teaspoon D_2 in the product.

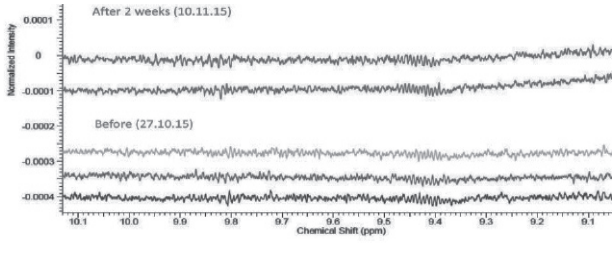
As discussed in a previous article (*Wise Traditions,* Fall 2015), it is likely that the form of vitamin D identified as D_2 by UBE labs is another, as yet unidentified, form of vitamin D.[8]

These results indicate that the unheated and fermented types of cod liver oil provide similar amounts of vitamin D, while the fermented cod liver oil is a better source of vitamin A.



Exposure to Air (14 days)	Site	c,t-alka-2,4-dienals	n-alkanals	neral	geranial	CHPDs
No	Lab 1	nd	nd	nd	nd	nd
No	Lab 2	nd	nd	nd	nd	nd
Yes	Lab 1	nd	nd	nd	nd	nd
Yes	Lab 2	nd	nd	nd	nd	~80

OIL 4: Steam-extracted cod liver oil showing no c,t-alka-2,4-dienals nor n-alkanals on opening or after two weeks. CHPDs (precursors to aldehydes) are present in one sample at two weeks after opening.



Exposure to Air (14 days)	Site	c,t-alka-2,4-dienals	n-alkanals	neral	geranial	CHPDs
No	Lab 1	nd	nd	nd	nd	nd
No	Lab 2	nd	nd	nd	nd	nd
Yes	Lab 1	nd	nd	nd	nd	nd
Yes	Lab 2	nd	nd	nd	nd	nd

OIL 5: Unheated fermented cod liver oil showing no signs of oxidation and good stability over two weeks.

FIGURE 2: DEVELOPMENT OF RANCIDITY IN CORN OIL AND LARD ON HEATING

Results are given in µmole (micromole) per mole of total fatty aids and represent the mean value of n=6 determinations.

(Courtesy Martin Grootveld, BSc, PhD, FIBMS, CBiol, FSB, FRSC)

Heating Time (min.)	trans-2-Alkenals	trans,trans-Alka-2,4-dienals	4-Hydroxy-trans-2-alkenals	cis,trans-Alka-2,4-dienals	n-Alkanals
0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
10	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
20	240 ± 60	170 ± 50	0.00 ± 0.00	0.00 ± 0.00	240 ± 50
30	500 ± 120	360 ± 80	0.00 ± 0.00	0.00 ± 0.00	420 ± 90
60	1320 ± 220	730 ± 100	380 ± 70	310 ± 50	800 ± 90
90	2330 ± 160	970 ± 70	540 ± 50	370 ± 30	1110 ± 70

LARD: Mean ± Standard Error (SEM) aldehyde concentrations generated in a commercial lard product exposed to thermal-stressing episodes for periods of 0-90 min. at 180°C (350°F) according to shallow frying practices.

Heating Time (min.)	trans-2-Alkenals	trans,trans-Alka-2,4-dienals	4-Hydroxy-trans-2-alkenals	cis,trans-Alka-2,4-dienals	n-Alkanals
0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
10	330 ± 20	280 ± 20	140 ± 10	150 ± 10	310 ± 25
20	870 ± 70	820 ± 70	290 ± 20	330 ± 25	660 ± 60
30	1520 ± 110	1380 ± 100	430 ± 25	480 ±330	1030 ± 90
60	3440 ± 330	2570 ± 220	900 ± 70	810 ± 80	1870 ± 230
90	5320 ± 610	3090 ± 250	1290 ± 110	970 ± 90	2480 ± 330

CORN OIL: Mean ± Standard Error (SEM) aldehyde concentrations generated in a commercial corn oil product exposed to thermal-stressing episodes for periods of 0-90 min. at 180°C (350°F) according to shallow frying practices.

FIGURE 3: *TRANS* FATTY ACIDS IN COD LIVER OIL

Oil 1	Molecularly distilled with added vitamins	2.73%
Oil 2	Molecularly distilled with no added vitamins	2.04%
Oil 3	Unheated	1.85%
Oil 4	Steam extracted	2.48%
Oil 5	Fermented	3.06%

FIGURE 4: VITAMINS A AND D IN COD LIVER OIL

TOTAL RETINOL (IU/TSP)	Covance	UBE	Retinol + Palmitate
Molecularly distilled, with no added vitamins	305	885	1005
Unheated	1890	2320	4130
Fermented	3125	3445	6080

VITAMIN D (IU/TSP)	Covance D3	COVANCE D2	UBE D3	UBE D2
Molecularly distilled, with no added vitamins	<4	<2	0	540
Unheated	198	<2	0	1570
Fermented			0	1645

WAPF sent samples of the three types of cod liver oil to VitaK Laboratories in the Netherlands for vitamin K testing. None of the samples analyzed showed appreciable amounts of vitamin K.

TAKING COD LIVER OIL

One individual has reported the development of heart problems after taking large amounts (about three tablespoons per day) of fermented cod liver oil for a period of several years, and some individuals have complained that the fermented cod liver oil causes a burning in the throat. Others have reported that all types and brands of cod liver oil cause nausea or burping. One individual has reported that taking cod liver oil led to food intolerances.

On the other hand, many practitioners report excellent results using the fermented cod liver oil, especially in raising vitamin D levels. This author has found the fermented cod liver oil extremely effective in relieving symptoms of allergy. Many children have thrived on the fermented cod liver oil.

Obviously, no one food will agree with everyone, and no one should take any food rich in chemically fragile omega-3 polyunsaturated fatty acids in excess, especially over a long period. The phenols in fermented cod liver oil may be one explanation for the throat burning—unfiltered olive oil, rich in phenols, can have the same effect. Indigestion and throat burning are also signs of niacin (vitamin B_3) deficiency.[9]

Cod liver oil is rich in vitamins A and D, and in unsaturated fatty acids, especially EPA. Taking generous amounts of vitamins A and D without vitamin K may lead to coronary artery disease, bone problems, tooth decay and gum disease. Large amounts of unsaturated fatty acids that are not balanced by dietary saturated fats may result in low hormone production, cancer, autoimmune disease and many other problems. EPA in cod liver oil without arachidonic acid from animal fats like butter may lead to skin disorders and digestive problems. And while cod liver oil contains DHA, additional amounts may be required from organ meats and egg yolks to balance high levels of EPA in cod liver oil.

Taking cod liver oil is all about balance. In small amounts in the context of a diet rich in egg yolks, butter, ghee or butter oil, cheese, poultry fats and poultry liver, organ meats and saturated meat fats, cod liver oil usually provides important benefits. This research indicates that all types of cod liver oil pose minimal safety problems when taken in small doses. Molecularly distilled cod liver oil without added vitamins contains very little vitamin D and is not recommended.

Sally Fallon Morell is the author of the bestselling cookbook Nourishing Traditions*, along with other titles. She is the founding president of the Weston A. Price Foundation and founder of A Campaign for Real Milk. This article is based on her presentation, "The Fat-Soluble Activators," given at the 2015 Wise Traditions conference.*

REFERENCES

1. http://www.westonaprice.org/health-topics/cod-liver-oil-manufacturing/; http://www.westonaprice.org/health-topics/cod-liver-oil/constant-controversy/.
2. http://drkaayladaniel.com/hook-line-and-stinker-opt-in/.
3. http://blog.cholesterol-and-health.com/2015/08/weighing-in-on-fermented-cod-liver-oil.html.
4. Claxson AW and others. . Generation of lipid peroxidation products in culinary oils and fats during episodes of thermal stressing: a high field 1H NMR study. FEBS Lett. 1994 Nov 21;355(1):81-90.
5. Personal communication, Martin Grootveld.
6. Gutfinger T. Polyphenols in olive oils. *Journal of the American Oil Chemists Society*. November 1981, Volume 58, Issue 11, pp 966-968; Velasco J and Dobarganes C. Oxidative stability of virgin olive oil. *European Journal of Lipid Science and Technology*. Volume 104, Issue 9-10, pages 661–676, October 200,
7. Hiroshi K and others. Biosynthesis of *trans* Fatty Acids in a Fungus, Cladosporium sphaerospermum, and Some Bacteria Isolated from Fish Viscera. Biosci. Biotech. Biochem., 60 (II), 1888-1890, 1996.
8. http://www.westonaprice.org/health-topics/cod-liver-oil/vitamin-d-in-cod-liver-oil/.
9. http://www.merckmanuals.com/home/disorders-of-nutrition/vitamins/niacin.

TAKING COD LIVER OIL: IT'S ALL ABOUT BALANCE