

Overview

Before one can discuss rancidity in oils its important to understand exactly what it is and how it is caused. There are three catalyysts that facilitate rancidity: light, heat, and air. This explains why most essential oils are packaged in light proof containers, kept in cold storage and usually filled with nitrogen. Ground flax contains less oil and therefore less susceptible to oxidation.

Free radical deterioration is one cause of rancidity. Free radicals are unpaired electrons in search of a partner. Electrons prefer to travel in pairs. If they become orphaned from their partner, their immediate response is to find another partner. The orphaned electron then steals an electron from a different molecule creating a new orphan. Then the newly orphaned electron steals an electron from yet another molecule, and so it goes on and on. This molecular chain reaction creates the basis of many negative things in the body. Cancer is believed to be formed by free radical damage to DNA causing mutations in cellular activity. Aging is believed to be linked to the accumulation of free radical damage to body over time.

The by-product of this process is the creation of peroxides. Measuring a fatty acids peroxide value will yield the level of amount of rancidity present. Studies below are separated into three sections: storage stability of whole & ground flaxseed, cooking stability of flaxseed, and stability of flaxseed in commercial products.

Storage Stability of Whole & Ground Flaxseed

- Chen Z-Y, Ratnayake WMN, and Cunnane SC. "Stability of Flaxseed during Baking." *Journal of American Oil Chemists Society* 71 (1992): 629-632.
Summary: One gram samples of whole flaxseed, milled flaxseed, and extracted flax oil were held in individual sealed glass tubes for 280 days (approx 10 months) at room temperature with 12 hours alternating dark/light cycles. All 3 preparations showed little change in head space oxygen during this time although the flax oil sample was more variable. The fatty acid composition of all three samples remained unchanged suggesting that alpha-linolenic acid(ALA) was stable to both heat and light. Lignans were not measured.
- Ratnayake WMN, Behrens WA, Fischer PWF, L'Abbe MR, Mongeau R. and Beare-Rogers JL. "Flaxseed: Chemical Stability and Nutritional Properties." *Journal of Nutritional Biochemistry* 3 (1992): 232-240.
Summary : Whole and ground flaxseed were stored for 44 weeks (about 10 months) at 39 degrees F and 72 degrees F. Both the fatty acid composition and peroxide value remained virtually unchanged. Lignans were not measured.

- Malcolmson LJ, Przybylski R, and Daun JK. "Storage Stability of Milled Flaxseed." *Journal of American Oil Chemists Society* 77 no.3 (2000): 235-238. Summary : Two samples of flaxseed were milled and stored at 73 degrees F for 128 days (4 months) in paper bags with plastic liners. Samples were evaluated at 0,33,66,96 and 128 days for chemical, sensory and volatile indicators of quality. Both flax samples showed very little increase of peroxide values or change in ALA content. A trained sensory panel could not detect a difference between fresh and stored samples, by odor or taste.
- Daun JK. "Additional Data on the Storage Stability of Milled Flaxseed." *Journal of American Oil Chemists Society* 78 no 1(2001): 105-106. Summary : Milled flaxseed (packaged in loosely closed plastic bags and protected from light) was stored in warehouse conditions at room temperatures for up to 20 months. Peroxide levels were relatively unchanged and the ALA content was intact.
- Wiesenborn D, Tostenson K, Kangas N, and Osowski C. "Mechanical Fractionation of Flaxseed for Edible Uses". *Proceedings of the 59th Flax Institute of the U.S.* (2002): 25-29. Summary : Two sets of samples, one had milled flaxseed spread out in trays exposed to air at 40 degrees C(104 degrees F); the other set had milled flaxseed stored in closed containers (plastic bags within paper bags) at room temperature. All samples were stored in the dark for up to 22 weeks. Flaxseed spread out in trays showed substantial deterioration (high peroxide levels) by 14 weeks. Flaxseed stored in bags showed very little increase in peroxide levels and fatty acids were unchanged.

Cooking Stability of Flaxseed

- Ratnayake WMN, Behrens WA, Fischer PWF, L'Abbe MR, Mongeau R, and Beare-Rogers JL. "Flaxseed : Chemical Stability and Nutritional Properties." *Journal of Nutritional Biochemistry* 3 (1992): 232-240. Summary : Whole and milled flaxseed was heated for 60 minutes at either 212 degrees F or 662 degrees F. No changes in peroxide values and fatty acids composition were noted.
- Chen Z-Y, Ratnayake WMN, and Cunnane SC. "Stability of Flaxseed during baking." *Journal of American Oil Chemists Society* 71 (1992): 629-632. Summary : Baked whole and milled flaxseed at 350 Degrees F for 90 minutes, no changes in fatty acid composition. Muffins made with flaxseed were baked at

350 degrees F for 2 hours. No change was noted in the ALA content, and other fatty acids.

- Cunnane SC, Hamadeh MJ, Liede AC, Thompson LU, Wolever TM, and Jenkins DJ. "Nutritional attributes of traditional flaxseed in healthy young adults." *American Journal of Clinical Nutrition* 61 (1995): 62-68.
Summary : Healthy, young adults (22-28 yrs. Old) [n=10,5 female, 5 male] ate 2 muffins each day (total of 50 grams milled flaxseed) for 4 weeks. Each adult stored their weekly muffin supply in the freezer and defrosted when needed. Baking the muffins did not change the ALA content and the thiobarbituric acid-reactive substances (another measurement of rancidity). In the adult subject, the antioxidant vitamins retinol and alpha-tocopherol remained unchanged in the plasma; products of lipid peroxidation in plasma and urine also remained similar to control group (no flax).
- Cunnane SC, Ganuli S, Menard C, Liede C, Hamadeh MJ, Chen Z-Y, Wolever TM, and Jenkins DJ. "High alpha-linolenic acid flaxseed : some nutritional properties in humans." *British Journal of Nutrition* 69 (1993):443-453.
Summary : Nine college women consumed 50 grams milled flaxseed for 4 weeks two different ways. Five women ate the milled flaxseed raw, to their food of the choice, such as breakfast cereal, soup, juice, or yogurt. Four women consumed bread baked with milled flaxseed in place of their usual bread. The plasma fatty acid profile were not significantly different between the two groups. This shows that baking did not effect the bioavailability of flaxseed fatty acids. The MDA (malondialdehyde) [Lipid peroxidation product] was not significantly increased in the muffins, hence baking time and temp did not affect it. Thiocyanate excretion was reduced below detectable limits in the muffin group, so cooking it seemed to eliminate it. Other group showed thiocyanate excretion slightly, and relative to creatinine excretion.
- Nesbitt PD, Lam Y, and Thompson LU. "Human metabolism of mammalian lignan precursors in raw and processed flaxseed." *American Journal of Clinical Nutrition* 69 (1999): 549-555.
Summary : Nine women ate 5,15, or 25 grams milled raw flaxseed (in applesauce) or 25 grams processed (muffin or bread) daily for eight days. Urinary lignan levels were similar no matter how the flax was consumed.

Stability of Flaxseed in Commercial Products

- Muir AD and Westcott ND. "Quantitation of the Lignan Secoisolariciresinol Diglucoside(SDG) in baked goods containing flaxseed or flaxmeal." *Proceedings of the 56th Flax Institute of the U.S.*(1996): 81-85.
Summary : Samples of flaxbread, white bread, whole wheat bread, flax muffins, flax bagels and flax cookies were obtained from bakeries. SDG was found in all samples of flax containing baked goods - suggested that SDG was conserved during the baking process.
- Nesbitt PD, Thompson LU. "Lignans in Homemade and Commercial Products Containing Flaxseed." *Nutrition and Cancer* 29 (1997):222-227.
Summary : Twenty-five foods including raw flaxseed, homemade products containing flaxseed, and commercial breads and breakfast cereals with and without flaxseed were subjected to an in vitro fermentation designed to simulate the colonic environment necessary for the conversion of plant precursors to mammalian lignans. The homemade bread, muffin, and pizza dough (containing 6.2,8.0 and 13.2% respectively), were baked at 375 degrees F. The homemade pancake was griddle-baked at 400 degrees F for 10 minutes. Definitely showed an increase in the production of mammalian lignans of all foods tested. The amount of lignan production was linearly dependent on the percent flaxseed but was also influenced by other grains and the variety of flaxseed.
- Tarpila S, Aro A, Salminen I, Tarpila A, Kleemola P, Akkila J, Adlercreutz H. "The effect of flaxseed supplementation in processed foods on serum fatty acid and enterolactone." *European Journal of Clinical Nutrition* 56 (2002): 157-165.
Summary : Controlled, double-blind and cross-over manner study. Eight subjects were randomized to diet sequences AB or BA. Diet A meals contained 1.3 grams/100 grams ground flax and 5 grams/100 grams flaxseed oil. Also 3-4 grams/100 grams inulin and wheat fiber was added. B diet with non-supplemented foods served as control. Test subjects were on both diets for 4 weeks separated by a 4-week wash out period. Serum thiocyanate and blood cadmium values did not exceed reference values and there was no difference between diets.
- Manthey F., Lee R., and Kegode R. "Quality of Spaghetti Containing Ground Flaxseed" *Proceedings of the 59th Flax Institute of the U.S.* (2000): 92-99.
Summary : Macaroni was fortified with 20% (by weight) ground flaxseed. Quality of spaghetti was better with fine than with coarse ground flaxseed. Protein stayed intact.
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Summary of Storage and Cooking Stability Studies

- Manthey F., Lee R., and Hall C., "Stability of Alpha-Linolenic Acid in Macaroni containing Ground Flaxseed" *Proceedings of the 59th Flax Institute of the U.S.* (2002): 14-20.
Summary : Macaroni was fortified with 20% (by weight) ground flaxseed and sampled every 2 weeks for the first 12 weeks and then every 4 weeks for the following 20 weeks (study lasted for 32 weeks). Macaroni was cooked in boiling water for 12 minutes. ALA remained the same during the whole storage process and after cooked.
- Manthey F., Lee R., and Hall C., "Processing and cooking effects on lipid content and stability of alpha-linolenic acid in spaghetti containing ground flaxseed." *J. Agric Food Chem* 50 (2002): 1668-1671.
Summary : ALA remained stable during the processing and cooking of spaghetti fortified with ground flaxseed.