Effect of dietary arachidonic and docosahexaenoic acid on polyunsaturated fatty acid levels of retina, liver and heart in the guinea pig

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Our previous studies have shown that retinal function in the guinea pig is influenced by the proportion of docosahexaenoic acid (DHA) in the retina. In these studies guinea pigs were fed for 3 generations on defined diets containing [1] safflower oil (SO rich in linoleic acid and poor in alpha-linolenic acid), [2] guinea pig chow or [3] a canola oil (CO) diet. Retinal DHA values were measured and compared with electroretinographic (ERG) function. The results showed that the safflower oil diet led to more than a 90% reduction in retinal DHA relative to the CO diet, and that the ERG signal was significantly reduced in guinea pigs on the safflower oil diet.

The aim of the present study was to determine the effect of dietary DHA and arachidonic acid (AA) on the long chain polyunsaturated fatty acid (PUFA) composition of retina, liver and heart in the guinea pig. Female pigmented guinea pigs (3-weeks old) were fed for 12 weeks on one of five semi-synthetic diets (n=14/group), containing 10% (w/w) lipid. All diets were designed to provide approx. 17% of the fatty acids as linoleic acid. In diets S and C the lipids were mainly provided by safflower oil and canola oil, respectively. These diets had linoleic acid/linolenic acid ratios of >200:1 and 2.3:1, respectively. Diet A was based on mixed vegetable oils with a fatty acid composition similar to that of human milk (linoleic acid/linolenic acid ratio of 17:1). In diet A1, some of the oleic acid was replaced by AA and DHA (1% of the fatty acids as AA and 0.7% as DHA simulating the level found in human milk), and diet A3 contained 3% AA and 2.1% DHA. The AA and DHA were obtained from microalgal sources and the tissue phospholipid fatty acids were examined by capillary GLC.

In the retina, the DHA levels increased in the order S<A<C<A1<A3. Supplementation with DHA and AA (at x1 and x3) compared with the diet A increased the retinal DHA proportion from 9.7% to 17.6% and 25.5%, respectively. The proportion of retinal DHA on the C diet (LA to ALA of 2.3:1) was similar to that obtained on the A1 diet (+ 0.7% DHA). In the heart, the DHA proportions were very low for diets without LCP. The DHA values increased from 0.4% for diet A to 5.9% and 5.6% for diets A1 and A3, respectively. In the liver, the DHA proportions were less than 1% for diets S, C and A. Supplementation with DHA increased the value to 6.1% and 14.6% for diets A1 and A3, respectively. The proportion of retinal AA was between 8.7% to 9.2% for all diet groups. In the liver, supplementation with AA increased the value from 7.6% on the A diet to 15.6% and 19.6%, respectively on the A1 and A3 diets. In the heart, the AA levels were highest for all three tissues (>20%), and AA supplementation had a relatively minor effect on heart AA proportions.

These data show that retinal DHA levels can be substantially increased by dietary manipulation of n-3 PUFA (either as alpha linolenic acid or as DHA). Consumption of both DHA and AA by weanling guinea pigs, as a balanced addition to their diet, was associated with accretion of DHA in retina, liver and heart, without affecting the tissue AA levels in the retina.