Enrichment of pork with DHA Omega-3 fats

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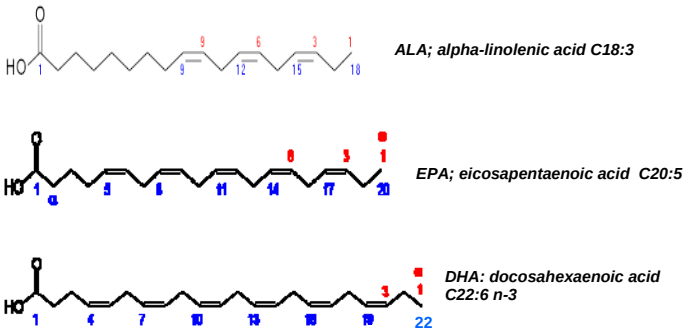
In order to improve cardiovascular health, a new value added marketing trend has begun to increase the omega-3 fatty acid content in food products. The essential dietary fats required by humans are omega-6 linoleic acid (LA) from corn and omega-3 alpha linolenic acid (ALA) from flax. These fatty acids are 18-carbon chains with unsaturated double bonds starting at the 6th or 3rd carbon from the methyl end (see figure 1).

Figure 1: Chemical structure of the omega-3 essential fatty acids ALA and the longer chain omega-3 fatty acids EPA and DHA



A balanced diet should have a ratio of, three to one, LA to ALA[1]. Unfortunately, the typical North American diet is closer to a thirty to one. In order to balance our diets better, we are recommended to increase our consumption of plants such as flax, canola which are both good sources of dietary C18 ALA omega-3 lipids. Eggs, meats, and dairy products that have been enriched with omega-3 are now being made available to the consumer: Omega-3 Pork (Prairie Orchard Farms, Vitapork (JSR Genetics), omega-3 yogurt (Yoplait, Ultima Foods Inc.) and Omega-3 eggs (National Egg Inc.).These products are enriched by feeding the animals, flax or canola.

Figure 2: Fields of flax

However, feeding just plant derived omega-3 fats might not be enough for maximum health. The human body can synthesize many long chain omega-3 fats from C18 ALA but the process is inefficient with a conversion rate of less than 10% and now there is an increasing body of evidence that although not essential, longer chain omega-3 fats are needed in our diets to moderate metabolic activity and inflammation. For example, a special long chain C22 omega-3 fat, docosahexaenoic acid (DHA) accounts for almost 10% of the total lipids in the human brain. DHA can be made from ALA under normal conditions but during early development, when demand is higher, extra dietary sources are probably needed since DHA supplements in infant formula improve IQ tests[2]. Another example of the benefits of fish oils is in the case of rheumatoid arthritis, characterized by painful inflammation of the joints between bones. Clinical studies have shown that dietary supplements of fish oil can relieve RA inflammation to point that many patients can stop taking aspirin and Tylenol medicines. RA inflammation is reduced because the inflammation signaling hormones, *prostaglandins, leukotrienes, lipoxins* made by the white blood cell enzymes cycloxygenase (COX-2) and lipooxygenase (LOX), are much weaker when made from omega-3 fats, such as DHA derived *resolvin*[3]; Health Canada now recommends that we receive at least 100mg of long chain omega-3 fats daily and this amount be increased under special circumstances of reproduction or autoimmune disease.

The longer chain omega-3 fats are traditionally obtained by eating fish oils (cod liver oil) which provides a mix of C18 (ALA), C20 (EPA) and C22 (DHA). However, feeding fish oils to increase EPA and DHA are believed to cause fishy flavours and odours. This correlation between EPA/DHA oils and fish smells is partially incorrect. Fresh DHA and EPA oils as highly unsaturated lipids are relatively odorless. It when they are exposed to air and oxidized that they begin to take on the typical fish smell. The fish smell is really an unconscious association we make when smelling fish exposed to air. The main odour in old fish is primarily due to the chemical trimethylamine, which is a by-product of protein breakdown.

Another misconception is that omega-3 oils are produced by the fish. In reality, much of the fish long chain omega-3 fats are due to their consumption of marine microalgae. It is this microalgae that industry is actually using to produce pure DHA for use in human infant formula. In North America, the primary supply of pure DHA is a *Schizochytrium* microalgae that was originally isolated by the US Department of Energy (DOE) in their search for alternative biofuels[4]. Interestingly, the use of microalage as an alternative human food supplement has been common practice in China for thousand of years producing, vitamins, essential fats and proteins. For the food industry, the addition of long chain omega-3 fatty acids has become a choice between fish oils or microalgae oils based on cost and concern of environmental contaminants in ocean supplies.

Figure 3: Bulk microalgae culture courtesy of University of Texas

At Lacombe we have recently performed a trial to increase the content of DHA in pork products by either feeding the pigs algae biomass or by mixing food grade DHA (Martek Biosciences Corp.) into pork loins. We also tried preparing bacon from the animals fed the DHA microalgae biomass. The retention of fed fats from a daily dose of 20 grams can be as low as only a few milligrams. This is caused by low absorption rates from the gut and its metabolism into energy. If we really wanted to increase the amount of DHA in pork, a much more efficient process is the injection of DHA within a brine solution.

The goal of our trial was to reach 100mg DHA per serving dose of a 100gm chop. To maintain a fresh flavour, the diets and brine marinating mixture included extra vitamin E [100 IU/serving] to prevent fat oxidation. Protection against oxidation is a great importance to the food industry. Supplements from oregano oils and green tea to butylated hydroxytoluene (BHT) and ascorbic acid have all been used in regular food products. Consumers have little tolerance for oxidized polyunsaturated fats which is in conflict with reducing the amount of hydrogenated and saturated fat in our diets.

We have established that bacon made from pigs fed up to 20gm of DHA per day is acceptable according to limited Home Use Test (HUT) survey for flavour and odour scores. Also

acceptable were pork loins injected with 100mg DHA in a brine solution as compared with loins injected with sunflower oil. However future work is needed on improving the stability of these flavours. It appears that it's the amount of unsaturated fat content that influences flavour. Other labs have found that mixing lamb tallow fat into pork has the same problems as fish oil on flavour over time.

Figure 4: Pork belly ready for bacon process

To conclude, we can enrich the pork with a healthier fat according to current beliefs in the medical establishment. Whether long chain omega-3 fats have some extra benefits over short chain omega-3 fats is still being investigated. At AAFC-Lacombe, we are testing the effect of the dietary DHA lipids on the genetic response in the pigs using selected biomarkers for, fat metabolism, fat synthesis and disease inflammation. Future work will compare the pure DHA with the mixture of omega-3 oils from fish extracts (Ocean Nutrition Inc). We are what we eat; a healthier meat source will translate into healthier individuals.

If you are interested in this field and are curious to see just how far can this research go? Biotech in the US have recently developed transgenic pigs able to convert their own omega-6 fat into omega-3 by inserting roundworm genes[5] and in Japan, transgenic pigs have been developed, inserted with a spinach gene[6] to increase general overall unsaturated fat content.

References

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