

## ORGANIC MILK WORKSHOP

Food Standards Agency, Aviation House, London

1<sup>st</sup> June, 2007

### Introduction

Between August, 2006 and February, 2007 four letters were exchanged between Dr Kathryn Ellis, University of Glasgow and Dame Deirdre Hutton, Chair, Food Standards Agency on the subject of the fatty acid composition of organic milk. It was agreed that while organically produced milk can contain higher levels of  $\alpha$ -linolenic acid (ALA) than conventional milk, care must be taken when drawing conclusions as to the nutritional significance of this.

In principle, an increased ALA intake from organic milk could affect human health by two mechanisms. First, there may be intrinsic effects of ALA on human health. Second, in theory the conversion of ALA into the long chain n-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) by the human body may be fast enough to generate enough of these two fatty acids to exert their well established beneficial effects on health. The Agency pointed out that there is little if any evidence of intrinsic benefits of ALA on cardiovascular health. In addition, the Agency quoted evidence from a review suggesting that rates of conversion of ALA to EPA were only 8% and that rates of conversion to DHA were between 0.05% and 4% in men (Burdge *et al*, 2002). Dr. Ellis felt that these figures were underestimates and quoted a paper showing conversion rates of ALA to EPA of 21% and ALA to DHA of 8%, however this was only in women (Burdge and Wootton, 2002).

In order to discuss this and related nutritional issues further, a workshop was convened at the Food Standards Agency on 1<sup>st</sup> June, 2007. The workshop was chaired by Dr Elaine Stone of the Food Standards Agency. Dr Kathryn Ellis was invited to present her research results. Dr Graham Burdge, University of Southampton then reviewed the research on conversion of ALA to EPA and DHA. This was followed by a general discussion of the issues raised. A full list of attendees is given below.

### Dr Kathryn Ellis

Dr Kathryn Ellis described her research on the differences in the composition of conventional and organic milk. This research consisted of a three month pilot study and a twelve month main study. In both studies monthly milk samples were collected.

The pilot study compared milk from 5 conventional farms and 7 organic farms. Conjugated linoleic acid (CLA) was the only fatty acid measured and there were no differences between conventional and organic milk although a seasonal effect was noted. In addition there were no differences in the content of persistent organic pollutants (POP) or the mycotoxin Ochratoxin A between organic and conventional milk.

The main study compared milk from 19 conventional farms and 18 organic farms. Sixty fatty acids were measured in addition to CLA. There was no difference in the total fat content of organic and conventional milk. However, in organic milk the ratio of polyunsaturated fatty acid (PUFA) to monounsaturated fatty acid (MUFA) was higher than in conventional milk ( $P < 0.01$ ) and the total n-3 PUFA contents was also significantly higher ( $P < 0.01$ ) than conventional milk (Figure. 1). A seasonal effect on total n-3 PUFA was found in both types of milk. There was no difference in the CLA content of organic and conventional milk although the seasonal effect in both types of milk was confirmed.

Data were presented on the individual n-3 PUFA present in organic and conventional milks obtained either at the farm gate or after processing. In all four types of milk, ALA made up ~75% of the total n-3 PUFA. The ALA and EPA contents of the two organic milks were higher than those of the corresponding conventional milks.

The total n-3 PUFA content of organic and conventional dairy products was estimated. Full fat organic dairy products would thus contain more total n-3 PUFA than conventional dairy products e.g. 200 ml milk contains 90 mg rather than 50 mg, 30 g cheese contains 110 mg rather than 73 mg and a 150 g pot of yogurt contains 200 mg rather than 120 mg.

There was no difference in the vitamin E or  $\beta$ -carotene content of organic and conventional milk although the vitamin A content of conventional milk was 15% higher.

The data on the fatty composition of organic and conventional milk have been published recently (Ellis *et al.* 2006). In agreement with these results, it had previously been shown that clover silages increase the ALA content of milk (Dewhurst *et al.* 2003).

### **Dr Graham Burdge**

Dr Graham Burdge then presented a review of the research on the metabolism of ALA in humans (Burdge and Calder, 2005). Conversion to EPA and DHA is only one metabolic fate of ALA. Other fates include  $\beta$ -oxidation, storage in adipose tissue and incorporation into cell membranes or circulating lipids. The proportion of ALA used in  $\beta$ -oxidation is about 50% greater in men than in women.

The classic pathway for the conversion of ALA to EPA and DHA involves a series of alternating desaturation and elongation reactions. However, it is now accepted that DHA formation takes place inside the peroxisome necessitating translocation from the endoplasmic reticulum. Control of this step has been suggested to allow independent regulation of EPA and DHA formation from ALA (Sprecher 2000).

Dr Burdge reviewed five stable isotope studies which attempted to provide quantitative estimates of ALA conversion rates into EPA and DHA (reviewed by Burdge and Calder, 2006). Comparisons between studies are difficult due to differences in design and data

presentation. However, Dr Burdge estimated that in men the conversion rate of ALA into EPA is 8% and the conversion rate of ALA into DHA is <0.05%. These rates are very low and are probably overestimates because of losses due to partitioning between metabolic fates in the liver which cannot be measured directly. Dr Burdge then reviewed nine dietary intervention trials which give some qualitative information on conversion rates of ALA into EPA and DHA (reviewed by Burdge and Calder, 2006). When the intake of ALA was plotted against changes in the proportion of EPA in plasma a positive relationship was obtained. By contrast, when the intake of ALA was plotted against changes in the proportion of DHA in plasma no relationship could be demonstrated. This suggests that while dietary ALA is a substrate for EPA synthesis, there is no significant conversion of ALA into DHA in men. The study by James *et al.* (2003) suggests that there is a constraint in conversion after docosapentaenoic acid (DPA) synthesis.

There are gender differences in the metabolism of n-3 PUFA. It has been shown that the conversion of ALA to EPA and DHA in women of reproductive age (Burdge and Wootton, 2002) were 2.5-fold and >200-fold greater respectively than in men of a comparable age (Burdge *et al.* 2002). Conversion of ALA into EPA is 21% and to DHA is 9% (Burdge and Wootton, 2002). In addition, it has been shown that the rate constant for the conversion of DPA to DHA was approximately four fold greater in women than in men (Pawlosky *et al.* 2003). Although subject numbers were small (n=3) DHA synthesis from ALA was almost three times greater in women using an oral contraceptive pill (Burdge and Wootton, 2002). Accordingly there may be a role for sex hormones in regulating the latter part of the pathway.

Several studies have demonstrated that the concentration of DHA is higher in plasma lipids than in men (reviewed by Burdge and Calder, 2006). Treatment of post-menopausal women with the hepatic oestrogen receptor agonist raloxifene results in a dose response increase in plasma cholesteryl ester DHA concentration (Giltay *et al.* 2004). Finally, it has been shown that plasma phosphatidylcholine DHA increases dramatically half way through gestation (Postle *et al.* 2005). Taken together this evidence suggests that the greater capacity for DHA synthesis in women reflects the demand for this fatty acid by the fetus and neonate, possible to meet demands for DHA by the developing central nervous system.

Since there is competition for the  $\Delta 6$ -desaturase between the n-6 PUFA linoleic acid (LA) and the n-3 PUFA ALA then it is possible that the n-6:n-3 PUFA ratio in the diet might influence synthesis of EPA and DHA from ALA. Several studies have suggested that this ratio is not important (reviewed by Burdge and Calder, 2006). One study showed that increasing ALA intake from 1.7 to 9.6 g/day had no effect on either conversion of ALA to EPA or DHA or on plasma lipid EPA, DPA or DHA concentrations. Another study compared the effects of very high intakes of ALA (17g/day) and very high intakes of LA (17g/day) on rates of conversion of ALA into EPA, DPA and DHA. Rates of DHA synthesis remained consistently low and unaffected by intakes of ALA or LA. Finally, a recently published study has demonstrated that the absolute amounts of ALA and LA in the diet rather than the n-6:n-3 PUFA ratio, determine rates of ALA conversion to EPA (Goyens *et al.* 2006).

Dr Burdge concluded that men have a limited capacity to convert ALA into EPA and DHA. By contrast, women have a greater capacity for EPA and DHA synthesis from ALA and this capacity can be stimulated e.g. during gestation to provide the fetus with more DHA. The ratio of n-6:n-3 PUFA in the diet has very little effect on the conversion of ALA to EPA or DHA.

Dr Burdge also felt that there were a number of things we still do not know about linolenic acid and human health and hence it was premature to conclude that ALA supplementation has no beneficial effects on health in all population subgroups. Dr Burdge raised the possibility that ALA supplementation might be effective in women at raising circulating concentrations of EPA and DHA and hence improving cardiovascular and immune system health. In addition, he pointed out that ALA supplementation might be of benefit in circumstances when the demand for DHA synthesis increased such as in pregnancy.

## **Discussion**

Professor Philip Calder, University of Southampton pointed out that there are several situations where ALA supplementation might have health benefits e.g. in children who have huge demands for DHA for brain growth and in vegans where the long chain n-3 PUFA status may be compromised.

Lord Peter Melchett, Soil Association also felt that health benefits of ALA cannot yet be ruled out. In addition the dietary recommendation to eat two portions of fish per week, one white and one oily, could provoke a health versus environment conflict if fish stocks prove to be unsustainable. He went on to argue that other ways of increasing the United Kingdom population intake of n-3 PUFA might be more acceptable and convenient than oily fish. These might include increasing the n-3 PUFA composition of more commonly consumed foods such as milk.

Dr Kathryn Ellis acknowledged that the Agency had responded to her original concerns in two ways. First, the Agency website now displayed information on differences in fatty acid composition between organic and conventional milk. Second, the present workshop had provided an opportunity to discuss the nutritional implications of her findings on the fatty acid composition of organic milk in the context of other research. Finally, Dr Kathryn Ellis felt that organic dairy products could make a contribution to changing the n-3 PUFA intake of the United Kingdom population.

## **Conclusions**

There was agreement on the following points.

- Dietary recommendations should be based on peer reviewed scientific evidence.

- In the light of new scientific evidence, dietary recommendations may need to be changed or new recommendations made.
- At present there is no published scientific evidence for beneficial effects of ALA supplementation on cardiovascular health.
- However, there may be specific situations where ALA supplementation might prove beneficial to health e.g. pregnancy. At present these specific situations have not been researched adequately.
- Synthesis of EPA and DHA from ALA in men is very low. Hence, the beneficial effects of EPA and DHA on health are unlikely to be achieved in men by ALA supplementation.
- Synthesis of EPA and DHA from ALA in women is greater and it is possible that significant amounts of EPA and DHA might be obtained from ALA in women particularly when oestrogen levels are high.

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### **Attendees**

Dr Kathryn Ellis, University of Glasgow; Professor Philip Calder and Dr Graham Burdge, University of Southampton; Ms Rosie Palmer, the Organic Milk Supplier Co-op; Lord Peter Melchett, the Soil Association; Dr.Elaine Stone, Miss Emma Peacock, Mrs Donatella Howe, Dr.Alison Spalding, the Food Standards Agency; Dr John Stanley, Advisor to the Food Standards Agency on Diet and Cardiovascular Health.