Nutritional aspects of **oilseeds**

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Oilseeds are energy dense foods. Although they contain protein and carbohydrate, most of the food energy they provide is as fat. Oilseeds vary widely in their fatty acid composition, but tend to be rich in monounsaturated fatty acid (MUFA) or polyunsaturated fatty acid (PUFA). Some seed oils contain significant amounts of the essential fatty acid (EFA) ALNA, an n-3 fatty acid, and linoleic acid (LA), an n-6 fatty acid. From these two, the body can make all the fatty acids it needs.

Generally, whole oilseeds are a source of fibre, phosphorus, iron, and magnesium. Many oilseeds are also a source of vitamin E, niacin, and folate. Whole oilseeds also contain phytoestrogens, a group of substances including lignans and isoflavones. Phytoestrogens may provide a protective effect against coronary heart disease as they have been shown to have a lowering effect on blood cholesterol. Additionally, some phytoestrogens may have antioxidant properties (Goldberg, 2003).

Vegetable oils do not contain the same levels of macronutrients, vitamins, and minerals as whole oilseeds. In fact, apart from fat itself, vitamin E is the only nutrient present in appreciable amounts. Vegetable oils do, however, contain a range of phytochemicals.

Whole oilseeds

Relatively small amounts of whole oilseeds are eaten in Britain. The average weekly intake of nuts and seeds, including that of non-consumers, was 17g for men and 12g for women (Henderson *et al.*, 2002). Nuts and seeds did, however, contribute a small proportion of the total PUFA intake, providing 3% of cis n-3 PUFA intake in men and 2% of cis n-3 in women, and 2% of cis n-6 intake in both men and women (Henderson *et al.*, 2003a).

Oilseed meals

Oilseed meals are important in animal nutrition as they are used in feed compounds. Oilseed meals are high in protein, with most being over 40% (Young, 1982). They also contain about 10% carbohydrate and some fat (the amount of which is dependent on the efficiency of oil extraction, but values range from ~1 to 6% depending on the oilseed and method used for extraction) (Young, 1982).

Vegetable oil and spreads

Margarines and cooking fats are the major foods produced from vegetable oils. Historical data shows that household consumption of total fats and oils has decreased from 245g/person/week in 1942 to 186g/person/week in 2000. Household consumption of lard, margarine, and butter has decreased over time, with concomitant increases in vegetable oils, low-fat spreads and reduced-fat spreads (DEFRA & National Statistics, 2001).

Margarines and cooking fats are used in a variety of foods. Vegetable oils provide a number of specific functions, including batter aeration, emulsifying properties, flavour provision and improvement in keeping properties (Macrae *et al.*, 1993). Vegetable oils are also used for frying. Hydrogenated vegetable oils may, however, contain trans fatty acids.

Contribution of oilseeds to diets

From oilseeds a range of oils and spreads are produced. These products are used as an ingredient in or to cook other foods. It is therefore difficult to estimate the total intake of oilseeds and foods containing vegetable oils or fats produced from oilseeds.

Fat spreads are an important source of vitamin E, being the main contributor of adult vitamin E intake among British adults and the second most important source among British children and young people. Excluding butter, they contribute

14% of total vitamin E intake in adults (Henderson *et al.,* 2003b), 17% in boys and 16% in girls (Gregory *et al*., 2000).

Fat spreads also contribute a significant proportion of vitamin D, with margarines and low-fat spreads contributing to 16% of intake in adults (Henderson *et al*., 2003b), 19% in boys and 19% in girls (Gregory *et al*., 2000). Fat spreads contribute to total vitamin A intake, but to a smaller extent.

Fat and health

Fat is an essential nutrient with a number of important functions. It carries fat-soluble vitamins and supplies EFAs, which are important structural elements of cell membranes and are essential for the formation of new tissues (Nettle, 1993). They are particularly important for the development of the brain, nervous system, and retina (BNF, 1999).

Body fat is an energy store and has been recognised as an endocrine gland, producing signalling molecules which play an important role in preventing the accumulation of body fat in tissues, other than the usual fat stores (Nugent, 2004b). The total amount of fat in the diet and the amount of the different fatty acids in the diet can influence health.

Fat and heart health

Generally, high intakes of saturated fatty acids and trans fatty acids have been associated with raised blood cholesterol levels, one of the risk factors associated with cardiovascular disease (CVD). In comparison, MUFA decreases the 'bad' LDL-cholesterol (LDL-C). While PUFA also decreases LDL-C, intakes of n-6 PUFA above 10% energy may have adverse effects on 'good' high density lipoprotein cholesterol (HDL-C) (Clarke *et al*., 1997).

Although n-3 fatty acids have little or no effect on total blood cholesterol levels, a substantial amount of work has focussed on their ability to reduce blood triacylglycerol levels. This, together with evidence that long-chain n-3 fatty acids reduce the risk of having a fatal heart attack, indicates an important role for long-chain n-3 fatty acids in maintaining heart health.

PUFA has also shown to influence insulin sensitivity, a key factor in the development of metabolic syndrome, abnormal blood lipids, insulin resistance, and high blood pressure. But to date, there is little support for a role in healthy people. There is also interest in the potential of fatty acids to influence endothelial function.

The majority of the work on heart health and n-3 fatty acids has focussed on long-chain n-3 fatty acids found in fish oils, rather than the shorter chain fatty acids found in oilseeds and their oils. In dietary studies, ALNA-rich oils do not appear to reproduce fish-oil-like effects on CVD risk factors (Sanderson *et al*., 2002). Nonetheless, a World Health Organization (WHO)/Food and Agriculture Organization of the United States (FAO) report on diet and chronic disease listed ALNA as a probable factor decreasing the risk of CVD (WHO/FAO, 2003).

In addition, soya protein has been associated with decreased cholesterol levels (Anderson *et al*., 1995), and in a three-month randomised study the isoflavone genistein was found to decrease blood pressure in subjects with mild hypertension (Rivas *et al*., 2002). However, it is unlikely that soya oil will have these effects as these components are removed during processing.

Fat and cancer

Some studies have indicated that there may be an association between fat intake and the risk of certain types of cancer, for example:

- Franceschi (1999) compared the diets of people with colorectal cancer to hospital controls. A high intake of saturated fatty acids seemed to be associated with an increased risk of colorectal cancer, while high intake of PUFA (chiefly olive and seed oils) showed a marginal inverse association with colorectal cancer risk.
- Another Italian case-control study found a reduced risk of ovarian cancer with a high intake of olive oil and for a group of specific seed oils (i.e. sunflower, peanut, and soya) (Bosetti *et al*., 2002).
- In the Norfolk component of the European Prospective Investigation into Cancer and Nutrition (EPIC) study, a relationship was found between saturated fatty consumption and breast cancer (Bingham *et al*., 2003).

Although these studies may suggest a role for fatty acids in cancer, findings from such case-control studies are weak and need to be verified by randomised controlled trials.

Fat and obesity

Fat is a concentrated source of energy, providing twice as much energy per gram as protein or carbohydrate. It has been suggested that it may be easier to consume an excess of energy when eating a high-fat diet, as fat-rich foods have a poor satiating power compared with protein and carbohydrate-rich foods.

If energy intake and expenditure are unbalanced, then the excess energy is stored in the body as fat, potentially leading to an individual becoming overweight or obese. Although the replacement of saturated fatty acids with carbohydrates has been the standard advice for weight loss, high carbohydrate diets have been shown to increase plasma triacylglycerol and decrease beneficial HDL-C levels. There is considerable debate about the most effective balance between carbohydrate and fatty acid profile.

Other roles of fat in health

Diabetes

Because of the reported effects of n-3 fatty acids on blood insulin levels, there has been some interest in the potential of n-3 fatty acids to influence type 2 diabetes and associated risks (Lovejoy, 1999). Work in animal models has shown that long-chain n-3 fatty acids improve insulin sensitivity compared with n-6 PUFA (Storlein *et al.*, 1991), although work in obese patients with impaired glucose tolerance given fish oil supplements for two weeks did not affect fasting concentrations of glucose and insulin, nor induced glycaemia and insulin response (Fasching *et al.*, 1991).

Inflammatory conditions

EFAs are used in the body to produce eicosanoids, which participate in inflammatory and immune responses. As n-3 fatty acid derived eicosanoids are generally less potent than those derived from n-6, it has been suggested that decreasing the dietary n-6/n-3 ratio may be beneficial in a number of conditions that involve abnormal immune responses, such as asthma, Crohn's disease, psoriasis, and rheumatoid arthritis. The evidence of a benefit of n-3 fatty acids in most of these conditions remains conflicting and/or weak (Prescott & Calder, 2004).

However, a review on the nutritional management of rheumatoid arthritis concluded that long-chain n-3 PUFA consistently demonstrated an improvement in symptoms and allowed a reduction in the use of non-steroidal anti-inflammatory drugs (Rennie *et al.*, 2003).

Cognitive function

Work in France studying the relationship between the fatty acid composition of erythrocyte membranes and cognitive decline in free-living volunteers found that a higher proportion of total n-3 fatty acids was associated with a lower risk of cognitive decline (Heude *et al.*, 2003). Several studies have found an association between dietary fat and fatty acids, and cognitive function and risk of dementia, with a reduced risk of cognitive decline or dementia associated with intakes of n-3 PUFA, particularly the long-chain n-3 PUFA associated with fish consumption (Kalmijn 2000; Morris *et al.*, 2003; Kalmijn *et al.*, 2004). However, these observations do not equate to causality and need to be verified in clinical trials.

Future developments

It seems people could benefit from increasing their consumption of n-3 PUFA, particularly those which are long-chained. Oil-rich fish is an excellent source of long-chain n-3 fatty acids, but alternative ways of increasing n-3 fatty acids are needed for several reasons. Firstly, many people do not eat fish. Secondly, as the majority of fish stocks are now being fully exploited, the recommendation to increase consumption of fish needs to be balanced against sustainability concerns (WHO/FAO Expert Consultation, 2003). Food manufacturers could use more n-3 rich PUFA in pre-prepared food products, as well as developing products which include n-3 rich oilseeds such as linseed and soya to help consumers increase their n-3 PUFA intake.

Plant biotechnology could also be used to produce plants with long-chain n-3 PUFA. The LIPGENE project is investigating this possibility by using transgenic technology to reproduce in oilseeds, the exact metabolic pathway responsible for the production of long-chain n-3 PUFA, thereby increasing the levels of n-3 PUFA in vegetable oil (Nugent, 2004a).

Another possibility is to manipulate the fatty acid composition of animal products by feeding livestock ALNA-rich oils or adding ALNA-rich seeds to feed. For example, Weil *et al.* (2002) reduced the n-6/n-3 ratio by 54% in butter, 60% in meat and 86% in eggs. Increasing PUFA levels may change flavour because of their greater susceptibility to oxidative breakdown and the generation of abnormal volatile compounds during cooking. In some but not all studies, the meat produced from pigs fed whole linseed had abnormal odours and flavours at a concentration of 3mg ALNA/100mg in muscle and fat tissue fatty acids (Wood *et al.*, 1999).

However, it has been demonstrated that consumption of products with increased n-3 contents can increase the n-3 content of plasma in humans, leading to a decrease in the n-6/n-3 (Weill *et al.*, 2002). The success of such a strategy will depend on the acceptability of the final products, the costs to industry, the willingness of the consumer to pay a premium price, and the presence of a strong scientific rationale.

Conclusion

Oilseeds and the products made from them have a role in a healthy, balanced diet even though they are energy dense and contain a high proportion of fat. They are particularly important sources of vitamins D and E, as well as contributing to vitamin A intake.

Oilseeds and their products are also rich sources of PUFA. While there seems to be important roles in health for PUFA, particularly in replacing saturated fatty acids in the diet, it may be particularly important to increase the n-3 family of PUFA rather than those belonging to the n-6 family.

The long-chain n-3 PUFAs are found in oily fish, but other ways of increasing intakes are needed. Innovative techniques may be needed, such as increasing the levels of n-3 PUFA in vegetable oil using transgenic technology, as well as increasing the n-3 PUFA content of animal products and highlighting to consumers good sources of n-3 PUFA.

This article has been abbreviated for publication in *Oilseeds Focus*. To read the full article, visit *www.academia.edu/5267109.*