EFFECTS OF MODIFICATION OF FATTY ACID COMPOSITION OF ANIMAL PRODUCTS ON ADOLESCENT FATTY ACID INTAKE IN BELGIUM

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Background

Over the last decades, much research has been devoted to the potential of modifying the fatty acid composition of animal food products, to better meet human nutritional guidelines. This research has mainly focused on increasing the content of polyunsaturated fatty acids (PUFA), aiming at increasing the P/S ratio (polyunsaturated/saturated fatty acids), on lowering the ratio of n-6/n-3 PUFA and on increasing the content of fatty acids with reported beneficial effects, e.g. long-chain PUFA and conjugated linoleic acids (Raes et al., 2004). There is little doubt that n-3 fatty acids are important in human nutrition (Connor, 2000).

There is growing interest in the animal feed industry to implement strategies fulfilling these objectives. However, the impact of such strategies on the actual fatty acid intake patterns of human population groups, and consequently the potential human health benefits, remain unclear. An assessment of the impact of strategies to modify the fatty acid composition of foods of animal origin on the fatty acid intake pattern of human populations is therefore desirable (Gibney, 1999). The outcome of such assessment could assist in evaluating the potential health benefits, which in turn need to be outweighed against the extra costs for implementing these strategies in the animal industry and against alternative strategies. A preliminary study was carried out in this regard, using human food consumption data and alternative fatty acid composition data of animal food products.

Objectives

To examine the impact of alterations in the n-6/n-3 PUFA ratio of animal foods on the pattern of fatty acid intake in the Belgian population. An alternative fatty acid composition profile for the major animal foods and two scenarios of implementation compared to a standard situation were considered.

Materials and methods

Food consumption data

Consumption data from a survey done in 1997 in a random sample of Flemish adolescents (aged 13-18 years; 129 boys and 212 girls) from the region of Ghent in Belgium were used. The dietary assessment method used was a 7-day diary, which was completed according to a standardised protocol. The database-architecture for this survey was generated on the basis of a commonly used Dutch dietary assessment tool, providing a detailed level of entries for food items (n=745 recorded in this study) (Unilever, 1992). A number of 527 foods contained fat following the food composition tables and were further used in this study.

Food composition data and fatty acid composition of animal products

Nutrient composition data routinely used in Belgium are those from the Belgian and the Dutch food composition tables (NEVO, 1993; NUBEL, 1992, 1995). However, differentiated data on the n-6 and n-3 PUFA are not available at the level of detail wanted in this study. The following approach was therefore adopted. The fat content of all food items was taken from the local food composition tables and was assumed to remain constant for the various scenarios analysed in this study. The origin of the lipid fraction was determined according to vegetable, land animal or marine origin or combinations thereof. The lipid fraction of land animal origin was further specified according to beef, pork, poultry, milk, eggs, sheep and horse. Subsequently, fatty acid content of the food items was obtained by linking the fat content and the contribution of the various lipid fractions to fatty acid proportions. For vegetable and marine fat sources, fatty acid proportions were taken from the McCance & Widdowson's and USDA food composition tables.

For land animal fat sources, two fatty acid composition profiles were considered for beef, pork, poultry, milk and eggs in the different scenarios envisaged in this study, i.e. a 'standard' and a 'n-3 enriched' fatty acid profile (Table 1). Because of the low intake of sheep and horse meat in Belgium, no alternative fatty acid composition was considered for these meats. Fatty acid composition was defined in terms of the sum of saturated fatty acids (SFA), the sum of monounsaturated fatty acids (MUFA), C18:2n-6 (linoleic acid, LA), C18:3n-3 (α-linolenic acid, LNA), C20:4n-6 (arachidonic acid, AA) and the sum of the long-chain n-3 PUFA C20:5n-3 (EPA), C22:5n-3 (DPA) and C22:6n-3 (DHA). The data were derived from a range of literature sources and from own information (for references see review of Raes et al., 2004). Values for the n-3 enriched profile were considered target values that could be obtained in commercial practice if feeds are including LNA rich sources, e.g. linseed and grass, at rather high levels that, however, do not compromise animal performances. The fatty acid composition of the meats was based on estimated contributions of intramuscular fat and subcutaneous fat (mainly for pork) and the differences in fatty acid composition between these fat depots. The use of fish oil or algae to increase the content of long-chain n-3 PUFA was not considered, hence higher levels of these fatty acids are resulting from elongation and desaturation of LNA.

Table 1. Standard (stand) and n-3 PUFA enriched (n-3) fatty acid profiles of the land animal fats assumed in this study (% w/w of total fatty acids)

	Beef		Pork		Poultry		Milk		Eggs		Sheep	Horse
	Stand	n-3	Stand	n-3	Stand	n-3	Stand	n-3	Stand	n-3	Stand	Stand
SFA	39.0	38.0	39.0	37.0	30.0	28.0	68.0	58.5	31.0	30.0	36.0	36.0
MUFA	39.0	38.0	39.0	37.0	38.0	36.0	25.0	32.0	41.5	39.0	35.0	34.0
C18:2n-6 (LA)	8.5	8.5	14.0	14.0	17.0	14.0	1.5	3.0	20.0	17.5	6.0	13.0
C20:4n-6 (AA)	1.5	1.5	0.4	0.4	3.0	3.0	0.0	0.0	2.0	1.0	2.2	1.7
C18:3n-3 (LNA)	1.0	2.0	1.5	5.0	2.5	7.0	0.5	1.3	1.0	7.0	1.5	7.5
LCn-3 (EPA, DPA, DHA)	0.5	1.0	0.3	0.5	2.0	4.5	0.0	0.0	1.5	2.5	2.8	1.6

Scenarios and calculations

Descriptive statistics and distributions for the intake of SFA, MUFA, LA, AA, LNA and LCn-3 PUFA were calculated for three scenarios, 1/ standard fatty acid composition of all land animal fats (Stand), 2/ n-3 enriched pork only (Pork+), 3/ n-3 enrichment of all land animal fats (All+). Scenario 2 and 3 correspond to a situation where all fattening pigs and all beef cattle, fattening pigs, poultry, dairy cows and layers, respectively, are fed diets high in LNA to achieve the fatty acid composition assumed in Table 1.

Results and discussion

Mean values for the intake of summarized and individual fatty acids in the different scenarios are given in Table 2. Mean values correspond reasonably well with data from an earlier study on the fatty acid composition of the Belgian diet, albeit in different population groups (Staessen et al., 1998). As expected, the largest changes in the mean fatty acid intake were observed for LNA and the LCn-3 PUFA. For LNA, the intake in g/p/d increased by 18% and 36% in the Pork+ and All+ scenario, respectively, compared to the standard scenario. The corresponding values for the relative increase of the LCn-3 PUFA intake are 6.5% and 35%. These changes were accompanied by a 6% decrease in the SFA intake in the All+ scenario, and relatively small increases in the intake of MUFA in the All+ scenario and in the intake of LA in the Pork+ and All+ scenario.

Table 2. Mean values for the fatty acid intake in the Standard, Pork+ and All+ scenario (gram/person/day, g/p/d and Energy%, E%)

Scenario	Standard		Pork+		All+	
	g/p/d	E%	g/p/d	E%	g/p/d	E%
SFA	35.8	14.4	35.6	14.3	33.6	13.5
MUFA	29.2	11.7	29.0	11.6	30.2	12.2
C18:2n-6 (LA)	14.1	5.65	14.5	5.83	14.7	5.90
C20:4n-6 (AA)	0.24	0.10	0.24	0.10	0.22	0.09
C18:3n-3 (LNA)	2.16	0.87	2.57	1.04	2.99	1.21
LCn-3 (EPA, DPA, DHA)	0.29	0.12	0.32	0.13	0.41	0.17

When the mean intake values are compared to nutritional recommendations (De Hoge Gezondheidsraad, 2003), none of the scenarios meet the criterium of SFA Energy% (E%) < 10. All scenarios meet the criteria MUFA E% > 10 and LA E% > 2. The mean value for the LNA E% is lower than the recommended value > 1 in the standard scenario, but exceeds this value in the Pork+ and All+ scenario. The recommended value for EPA+DHA E% > 0.3 was clearly not met in any of the scenarios. In addition, DPA was included in our data, making a significant contribution to the sum of the LCn-3 PUFA in land animal products. The average n-6/n-3 ratio dropped from 6.6 to 5.4 and 4.6 in the Pork+ and All+ scenario compared to the standard situation.

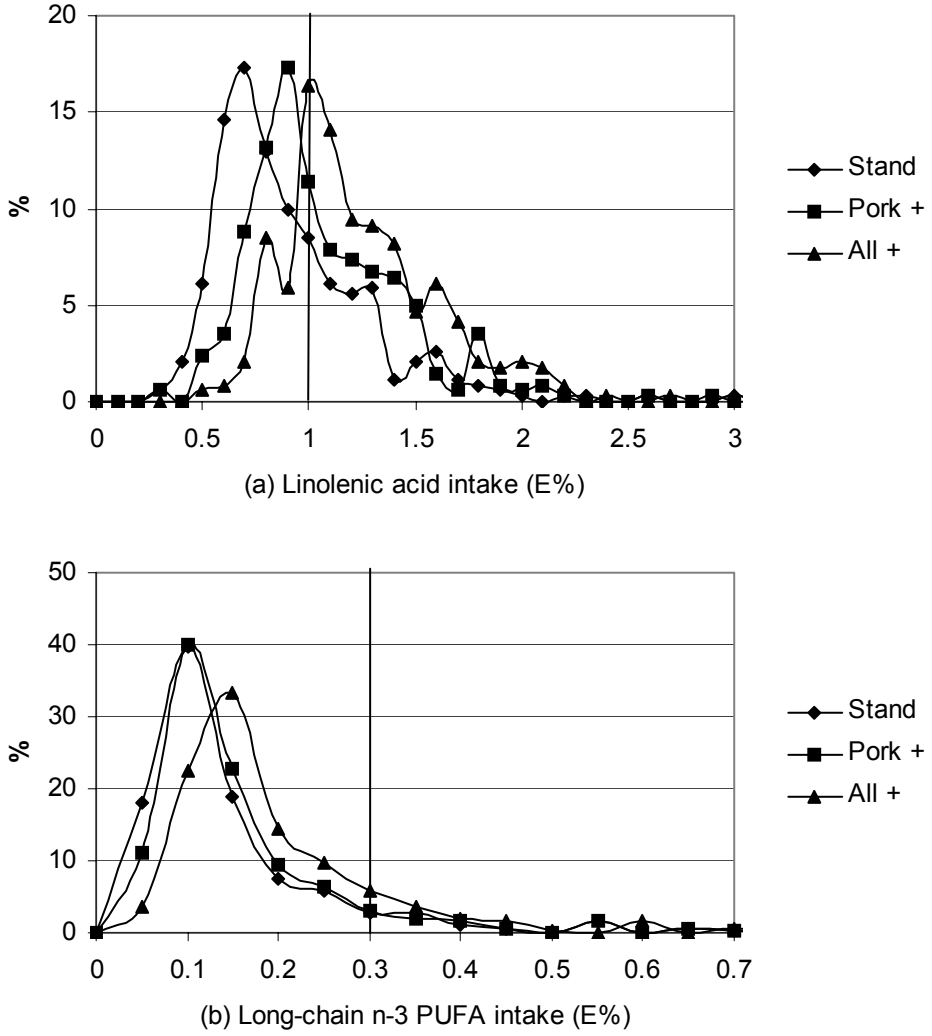

Figure 1. Distribution of the adolescent average daily intake of (a) LNA and (b) LCn-3 PUFA for the three scenarios (Energy%, E%). Vertical lines represent recommended minimum intake values.

The population distributions of the intake of LNA and LCn-3 PUFA are shown in figure 1. Interestingly, the largest increase in intake of these fatty acids occurs at the lowest intake levels. At high intake levels, there is almost no change, illustrating probably that a high intake of LNA and LCn-3 PUFA is not derived from land animal products, but from vegetable food sources and fish, respectively. High intake levels of the LCn-3 PUFA are only observed in a small part of the population, corresponding to the low average fish consumption in Belgium (De Henauw and De Backer, 1999). Staessen et al. (1998) calculated that meat was the most important source of n-3 PUFA in the Belgian diet. Hence, for a low-fish consumption population like in Belgium, strategies to increase the content of n-3 PUFA in land animal foods may be worthwhile. This may be even more valid in view of the increasing share of fish derived from aquaculture and the expected shift in fish feeding practices towards more n-6 fat sources.

This preliminary study has to be considered as a simulation study and an extrapolation to actual food intake patterns in the entire Belgian population is therefore speculative. Furthermore, the outcome of this kind of

assessment exercises is strongly determined by the assumptions made that may be debated at several points. Particularly the changes in fatty acid composition of the land animal fats in the alternative scenarios that were assumed may largely affect the outcome, e.g. a quite high reduction in the SFA content of 'n-3' milk was assumed, which may be responsable for the large drop in SFA intake in the All+ scenario. Similarly, the moderate increase in intake of LCn-3 PUFA in the Pork+ scenario compared to the relatively large increase in the All+ scenario may be due to a larger increase for the content of LCn-3 PUFA that was assumed for eggs, poultry and beef compared to pork. In addition, it is not very likely that an altered animal nutritional strategy will be adopted by the whole sector. Some modelling would be interesting in this respect, taking into account distributions in fatty acid composition instead of fixed mean values. Nevertheless, this preliminary study has shown the potential of this approach to evaluate the effects of alternative feeding strategies in the animal industry on human intake patterns. The potential impact on human health of these shifts in fatty acid intake is of course difficult to establish. In several human clinical studies using land animal foods with modified fatty acid composition following changes in the animals' diets, significant changes in the fatty acid composition of plasma and erythrocytes have been demonstrated (Sim and Nakai, 1994; Stewart et al., 2001; Weill et al., 2002). Hence, modification of the fatty acid composition of land animal foods may be a useful approach.

Conclusions

In this simulation study using Belgian food consumption data for adolescents, a relatively large but achievable enrichment in n-3 PUFA of either all pork or all major land animal products was calculated to increase the average daily intake of α-linolenic acid by 18% and 36%, respectively, and of the sum of long-chain n-3 PUFA by 6.5% and 35%, respectively. Although the outcome is largely affected by the assumptions that are made, this kind of assessment may help in evaluating the potential impact of new animal feeding strategies on human dietary intake and consequently on human health.

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