Are n-3 PUFA dietary recommendations met in in-hospital and school catering ?

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Abstract

Background : **Literature provides compelling evidence for the health benefits of n-3 polyunsaturated fatty acids (PUFA) consumption and low n-6/n-3 ratio, in particular, on inflammation and metabolic syndrome prevention and treatment. Consequently, recommendations were established for adequate n-3 PUFA supplies in the general population. The aim of our study was to evaluate the fatty acid (FA) profile in collective catering in relation to those recommendations.**

Methods : **We obtained composition of lunches provided by the Township of Lille (France) to children and adults, and of "standard", "low-fat" and "for diabetic" menus from the catering service of St Luc university hospital (Brussels, Belgium). The average proportions of fish, meat, oils, and dairy were used to estimate total, saturated, monounsaturated and polyunsaturated (n-6 and n-3) FA contents. We used official tables of foodstuffs composition provided by the French Agency for Food Safety, the project "Nutritional Composition of Aquatic Products", the French Institute for Nutrition, and the USDA National Nutrient Database for Standard Reference. French guidelines were taken as reference for daily recommended intakes.**

Results : **n-3 PUFA content in lunches provided by municipal catering and in in-hospital menus were slightly below recommended intakes. In the latter, n-3 PUFA enriched margarine contributed for 50% to daily intakes. Despite, the n-6/n-3 ratio was too high, especially in municipal catering (around 20), related to excessive n-6 PUFA supply.**

Conclusions : **Our results highlight that meeting n-3 PUFA nutritional recommendation remains challenging for collective catering. A detailed analysis of provided menus represents a powerful tool to increase awareness and foster improvement in practice.** (Acta gastroenterol. belg., **2011**, 74, **281-288**).

Key words : n-3 polyunsaturated fatty acids, catering, eicosapentaenoic acid, docosahexaenoic acid, alpha-linolenic acid, metabolic syndrome.

Introduction

The increasing prevalence of obesity, insulin resistance and metabolic syndrome (MetS) is paralleled by life-style changes characterized by a lack in physical activity and drifts in human nutrition and dietary habits, resulting in a relative excess/deficiency in some metabolically relevant nutrients. In particular, consumption of saturated fat (especially from meat) and vegetable oils rich in linoleic acid (LA, n-6 polyunsaturated fatty acid - PUFA) has increased, with total fatty acids (FA) representing 28-42% of total energy consumed today by European populations (1). In 1990, the daily consumption of FA was 128 g/d in developed countries while in 1961 it was estimated to be 93 g/d (2). Increased FA intakes together with insufficient consumption of fatty fish (3), nuts, seeds and whole-grain cereals (4) has led to an overall decrease in n-3 PUFA intakes relative to n-6 PUFA (5). Indeed, n-6 PUFA consumption has become progressively much higher than that of n-3 PUFA (6), so that in Western diets the n-6/n-3 ratio ranges from 10/1 to 20/1 for a ratio of 1/1 in the diet of our ancestors (7,8).

The essential PUFA of the n-3 series, namely eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA, found in fish oil) and alpha-linolenic acid (ALA, precursor of EPA and DHA, found in nut, soy and rapeseed oils), and of the n-6 series (arachidonic acid -AA- and LA, found in sunflower and nut oils) are the respective precursors for anti- and pro-inflammatory eicosanoids and autacoids (9-12) (Fig. 1). Marine fish and especially fatty ones are the most important source of n-3 PUFA in occident and almost the only source of long-chain (LC) n-3 PUFAs (EPA and DHA). Those are the most biologically active n-3 PUFA (13) as they generate protective derivates with anti-inflammatory, anti-steatosis and vascular protective effects through several mechanisms, including modifications in cell membrane composition, fluidity and function, modulation of gene expression, or production of distinct eicosanoids (11-16). Thus, considering that in humans, the conversion rate of ALA to EPA/DHA is low, exogenous sources of EPA/DHA must be present in the diet to ensure physiological protective levels of n-3 LC-PUFA.

Many studies conducted independently around the world have provided convincing evidence of the detrimental role of low dietary n-3 PUFA for the MetS and the cardiovascular risk (4,17,18). Conversly, distinct

Abbreviation list

ALA : alpha-linolenic acid ; DHA : docosahexaenoic acid ; DRI : dietary recommended intake ; EPA : eicosapentaenoic acid ; FA : fatty acids, LC PUFA : long-chain polyunsaturated fatty acids ; LDRI : Lunch dietary recommended intake ; MetS : metabolic syndrome ; MUFA : monounsaturated fatty acids ; NAFLD : non-alcoholic fatty liver disease ; PUFA : polyunsaturated fatty acids.

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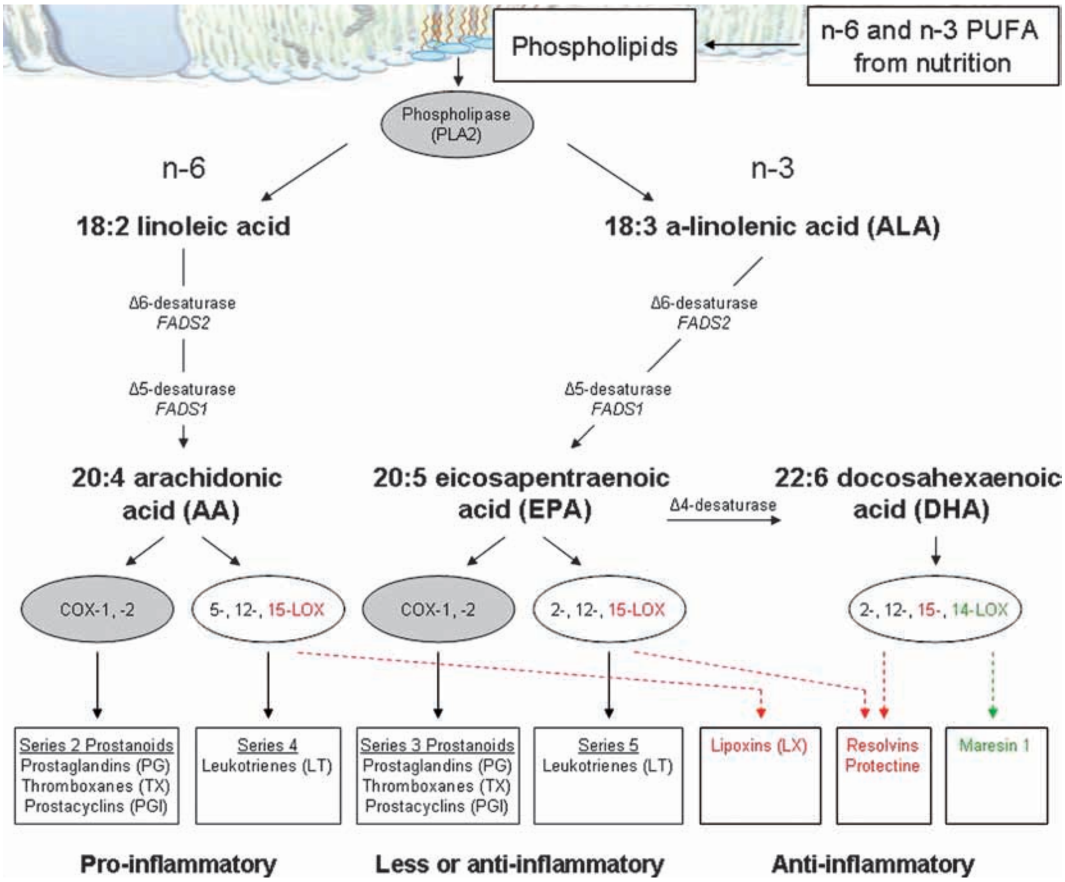
Submission date : 05/08/2010
Acceptance date : 10/01/2011



Adapted from (9-11). Modification of the 3D plasma layer image kindly dotated by Mélanie Villeneuve, La cellule animale, CCDMD, 2008 (http ://www.ccdmd.qc.ca/ri/cellule/index.php ?nh=18). COX : Cyclo-oxygenase ; LOX : Lipoxygenase.

Fig. 1. — Metabolism of polyunsaturated fatty acids and their signaling molecules

beneficial effects of n-3 PUFA consumption have been reported on insulin sensitivity, T2DM, lipid profile, MetS (9,19-23), dyslipidaemia (24,24,25), some cancers (26,27), and on the risk of coronary heart diseases (15,24,28-30). Those studies provide thus a strong support for adequate n-3 PUFA and EPA/DHA nutritional supplies both for the prevention of MetS and associated disorders in the general population and for secondary prevention or treatment.

In prospective and intervention studies reporting a beneficial health effect, EPA/DHA and ALA amounts were higher than initial recommendations (0.5 to 9 g/d *vs.* 0.6 to 1 g/d n-3PUFA from which 100-200 mg EPA/DHA) (29). Moreover, ancestral nutrition to which our metabolism is best fit, was estimated to provide 5-6 g/d of n-3 PUFA with a high proportion of EPA+DHA, and a n-6-to-n-3 ratio averaging 1 (7,8). Today, nutritional guidelines have been upgraded and the recommended total n-3 PUFA dietary intakes range from 1.4 to 2.5 g/d, of which 140 to 600 mg/d of EPA and DHA depending on the authority issuing the guidelines, with a n-6/n-3 ratio around 4-5 for adults (31,32). This roughly represents a minimum of 2-3 servings of fish per week (30-40 g/d), including one of oily fish (salmon, tuna, mackerel, sardine).

The aim of the present study was to investigate the quantitative and qualitative FA supplies in nutritionist-coordinated collective caterings. We calculated FA composition in lunches supplied by the Township of Lille (France) to pupils (4-6 and 6-10 years of age) and adults and in meals proposed to patients from the university hospital St Luc (Brussels, Belgium).

Materials and methods

Data collection

We obtained the exact composition and mode of preparation of meals provided by the Township of Lille (France) during six consecutive and representative weeks (from 22-02-2010 to 02-04-2010) proposed to school children (4-6 and 6-10 years of age) and to adults. We obtained average foodstuff proportions from the catering service of St Luc university hospital (Brussels, Belgium) for 4 weeks winter menus and 4 weeks summer menus that are proposed in rotation along the year. The standard, low fat menus as well as the menu for diabetic patients were analyzed.

Nutritional analyses

The amounts of fish, meat, oils, and dairy products used for preparation of meals (g) were used for calculations. We applied (i) the official tables of composition in saturated, mono- and poly-unsaturated FA of foodstuffs from the French Agency for Food Safety (33), (ii) the table of composition in n-6 and n-3 PUFAs of fish, meat, oils, and dairy products provided either by the project "Nutritional Composition of Aquatic Products" (34) or by the French Institute for Nutrition (35), and (iii) the EPA and DHA contents of specific foodstuffs provided by the USDA National Nutrient Database for Standard Reference (36).

Total FA, saturated FA (SFA), monounsaturated FA (MUFA), PUFA, n-6, n-3 and LC n-3 PUFA contents were calculated on the basis of the data provided by the caterings, averaged over the periods investigated and expressed as daily intakes (g/d/individual). Similarly, we calculated average daily consumption of main foodstuffs rich (or enriched) in n-3 and n-6 PUFA, namely fish, poultry, eggs, oils and fats.

Dietary guidelines

The French ANC guidelines (37) were taken as reference for daily recommended intakes (DRI) and calculated lunch daily recommended intakes (LDRI) as 35-40% of DRI, with a range representing minimum supplies for girls and maximum ones for boys (Table 1 and 3). The average of this range was used as reference for calculation of percentages of recommendations fulfillment (Fig. 2 and 3).

Results

Township catering

In collective lunches proposed by the Township of Lille whether to children or adults, the mean FA content was high and represented 117-140% of averaged LDRI (Table 1, fig. 2A). This was related to substantially elevated SFA intakes (116-148% of DRI), while MUFA were globally within the recommended range for children (75-91% of LDRI) and frankly low for adults (59% LDRI). In parallel, total and n-6 PUFA supplies were clearly excessive (265-380 and 316-440% of LDRI respectively). This was mainly attributable to systematic use of dressings prepared with extra-virgin safflower oil (11.3-11.5 g/d, table 2), which contains high amounts of n-6 PUFA (65%). n-3 PUFA contents were within the minimum range of LDRI and thus regarded as adaquate. This was related to substantial consumption of fish (18.6-31.1 g/d, table 2) with 8 servings over the 6 weeks menus, of which 4 were white fish (0.35% n-3), 2 were canned tuna (1.27% n-3), and 2 were salmon (2.25% n 3). Although DRI guidelines used in this study do not establish specific recommendations for EPA and DHA supplies for children, EPA/DHA content in lunches provided to children and adults was around 0.2 g/d, which covers two fifths of the daily recommendation for adults. Despite satisfactory n-3 PUFA contents, n-6/n-3 ratio was dramatically elevated (18-24/1) due to excessive n-6 PUFA supplies. If one half of safflowers oil (containing

Table 1. — **Fatty acids daily quantitative intakes (g/d/individual) in municipal and hospital catering**

		FA				PUFA			
		Total g/d/ind	**SFA g/d/ind**	**MUFA g/d/ind**	**PUFA g/d/ind**	**n-6 PUFA g/d/ind**	**n-3 PUFA g/d/ind**	**EPA+DHA g/d/ind**	**n-6/n-3 g/d/ind**
Lille municipal catering	**Children 4-6 y**	28.3	8.5	8.4	10.3	9.9	0.4	0.17	24.1
	LDRI min-max	*16.5-23.8*	*[a]5.5-6.8*	*6.6-11.9*	*1.3-4.1*	*1.1-3.4*	*0.2-0.7*		*5,00*
	Children 6-10 y	30.0	9.1	9.0	10.7	10.2	0.5	0.22	20.8
	LDRI min-max	*20.9-30.2*	*[a]5.6-7.8*	*8.4-15.1*	*1.7-5.2*	*1.4-4.3*	*0.3-0.9*		*5,00*
	Adults	32.6	10.0	9.9	11.3	10.8	0.6	0.26	18.6
	LDRI min-max	*23.1-32.4*	*[a]5.6-7.8*	*14.0-19.6*	*3.5-5.0*	*2.8-4.0*	*0.7-1.0*	*0.2*	*4,00*
St Luc Hospital Brussels	**Classic**	48.28	18.38	16.79	13.10/[b]11.90	11.24	1.92/[b]0.72	0.46/[b]0.26	5.86/[b]15.61
	Diabetic	54.15	20.16	17.52	16.47/[b]15.27	14.66	1.85/[b]0.65	0.46/[b]0.26	7.91/[b]22.55
	Low-fat	35.36	12.64	12.07	10.64/[b]9.44	8.9	1.79/[b]0.59	0.46/[b]0.26	4.96/[b]15.08
	DRI women-men	*66-81*	*[a]16.0-19.5*	*40.0-49.0*	*10.0-12.5*	*8.0-10.0*	*2.0-2.5*	*0.5*	*4,00*

DRI : daily recommended intakes ; LDRI : lunch DRI ; a : for SFA, LDRI ranges represent 35% of the maximum intakes for women and 40% of the maximum intakes for men ; b : values without enriched margarine. Results are expressed as g/d/individual.

Table 2. — **Average daily consumption of fish, eggs, poultry and fats**

Lille municipal catering	Fish (g/day)	Eggs (g/day)	Poultry (g/day)	Fats (g/day)			
				Margarine	Safflower oil	Palm oil	Olive oil
Children 4-6 y	18.6	9.0	19.0	9.8	11.3	0.2	0.3
Children 6-10 y	24.5	9.0	20.7	11.2	11.4	0.2	0.4
Adults	31.1	9.0	24.0	13.7	11.5	0.2	0.5
St Luc Hospital Brussels	Fish (g/day)	Eggs (g/day)	Poultry (g/day)	Fats (g/day)			
				Enriched margarine		Oils (mainly safflower)	
Classic	29.3	4.8	40.7	40.0		5.3	
Diabetic	29.3	4.8	36.4	40.0		11.2	
Low-fat	29.3	0.0	45.0	40.0		2.0	

Results are expressed as g/d/individual.

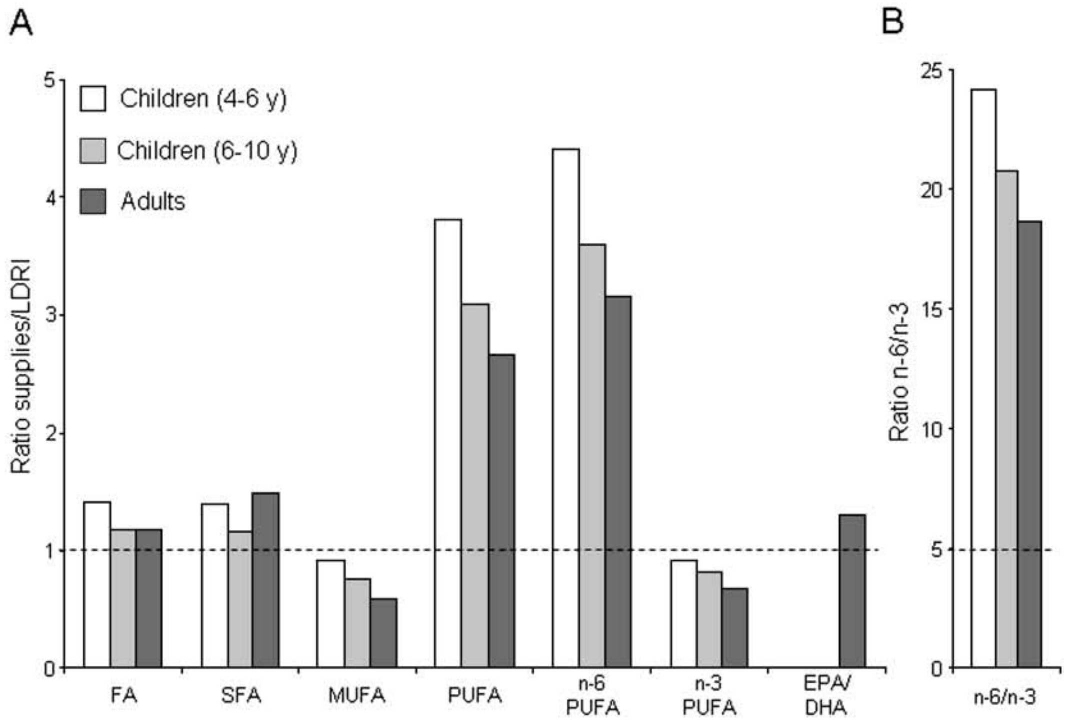


Fig. 2. — Fatty acids profile in Lille municipal catering
A : Fatty acids supplies expressed as ratios to their respective averaged LDRI (dotted line = 1) to infant school (empty bars), elementary school (light grey bars), and adults (dark grey bars). B : n-6/n-3 PUFA ratio, with recommendation being 4 for adults, and 5 for children (dotted line). The French ANC guidelines 2000 (37) were taken as reference for calculation and averaging of LDRI as 35-40% of DRI.

64% n-6 and 0.2% n-3) were to be replaced by rapeseeds oil (containing 20% n-6 and 9% n-3) in dressing, we would forecast a 50% reduction of the n-6/n-3 ratio as a result of both an increase in n-3 PUFA and a decrease in n-6 PUFA (Table 3).

In-hospital catering

In the meals proposed at St Luc University Hospital (Belgium), total FA were relatively low (Table 1) and represented 50%, 66% and 74% of DRI in low-fat, normal and diabetic menus, respectively (Fig. 3). This was related to dramatically low MUFA supplies (38% of DRI, and 27% for low-fat), while SFA were within the recommended range in normal and diabetic meals and 30% below DRI in low-fat meals. Classical and low-fat menus supplied the recommended amounts of total and n-6 PUFA, but they were out-leveled in the diabetic regimen, owed to the addition of 2 safflower-based dressings per day for lunch and evening salads (11.2 g/d, table 2). Total n-3 PUFA content was between 1.8 and 1.9 g/d (80-85% DRI) and up to 460 mg/d (92% DRI)

Table 3. — **Replacement of half safflower oil by rapeseeds oil : predictive effect on daily quantitative fatty acids intakes (g/d/individual) in lunches proposed by Lille municipal catering**

Population	FA				PUFA			
	Total g/d/ind	SFA g/d/ind	MUFA g/d/ind	PUFA g/d/ind	n-6 PUFA g/d/ind	n-3 PUFA g/d/ind	EPA+DHA g/d/ind	n-6/n-3 g/d/ind
Children 4-6 y	**28.4**	**8.4 (8.5)**	**10.0 (8.4)**	**8.7 (10.3)**	**7.9 (9.9)**	**0.8 (0.4)**	0.17	**9.8 (24.1)**
LDRI min-max	*16.5-23.8*	*[a]5.5-6.8*	*6.6-11.9*	*1.3-4.1*	*1.1-3.4*	*0.2-0.7*	–	*5,00*
Children 6-10 y	**30,0**	**8.9 (9.1)**	**10.6 (9.0)**	**9.1 (10.7)**	**8.3 (10.2)**	**0.9 (0.5)**	0.22	**9.3 (20.8)**
LDRI min-max	*20.9-30.2*	*[a]7.0-8.6*	*8.4-15.1*	*1.7-5.2*	*1.4-4.3*	*0.3-0.9*	–	*5,00*
Adults	**32.6**	**9.8 (10.0)**	**11.5 (9.9)**	**9.7 (11.3)**	**8.8 (10.8)**	**1.0 (0.6)**	0.26	**9.1 (18.6)**
LDRI min-max	*23.1-32.4*	*[a]5.6-7.8*	*14.0-19.6*	*3.5-5.0*	*2.8-4.0*	*0.7-1.0*	*0.2*	*4,00*

Bold numbers represent values upon replacement of 50% safflower oil by rapeseed oil. For reference, numbers in brackets refer to actual values i.e. 100% safflower oil (as in table 1). LDRI : lunch daily recommended intakes ; a : for SFA, LDRI ranges represent 35% of the maximum intakes for women and 40% of the maximum intakes for men. Results are expressed as g/d/individual.

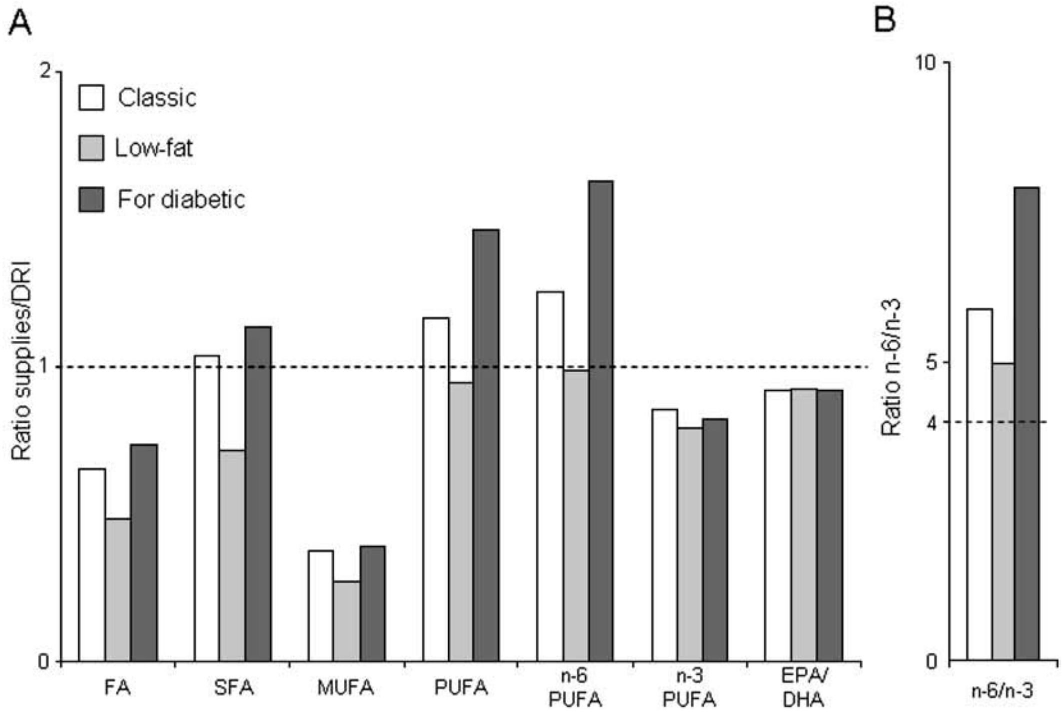


Fig. 3. — Fatty acids profile in university hospital St Luc catering
A : Fatty acids supplies expressed as ratios to their respective averaged DRI (dotted line = 1) in classic (empty bars), low-fat (light grey bars), and for diabetic menus (dark grey bars). B : n-6/n-3 PUFA ratio, with recommendation being 4 for adults (dotted line). The French ANC guidelines 2000 (37) were taken as reference for DRI and averaging.

EPA+DHA were provided, i.e. close to the recommended 2 g/d and 500 mg/d, respectively (37). Thus, n-6/n-3 ratio were between 5/1 and 8/1 in low-fat and diabetic menus, respectively (Fig. 2B), the recommendation being 4/1, with an ideal at 1/1. Noteworthy, 50% of n-3 PUFA and n-3 LC PUFA were supplied by n-3 PUFA enriched margarine : there were 2 portions/d (breakfast, diner, 40 g/d, Table 2) of such margarine that contains 16% n-3 PUFA (i.e.1.2 g/d) and 0.5% EPA+DHA (i.e. 0.2 g/d). Without consumption of this enriched product, and despite presence of 6 servings of fish as main dish (2 salmons, 4 white fishes) and 2 as evening complements (caned thuna or crab) during the 4 weeks period (29.3 g/d of fish, table 2), n-3 PUFA supplies would be insufficient (0.6-0.7 g/d, 0.26 g/d EPA/DHA) with a n-6/n-3 ratio higher than 15 (table 1).

Discussion

Consistent with other reports in the general population (6-8,27), our results highlight that reaching adequate or recommended n-3 PUFA supplies/intakes and n-6/n-3 ratio in nutritionist-assisted collective nutrition is still challenging when considering only naturally rich sources of n-3 PUFA. Indeed, the in-hospital and municipal catering investigated propose little n-3 PUFA and EPA/DHA from natural food. For people taking their lunch from collective catering, if the other meals do not provide fish or n-3 PUFA rich foodstuffs as abundantly as at lunch (i.e. 1-2 times per week for fish), daily intake will be insufficient. In in-hospital catering, an alternative to natural sources of n-3 PUFA has been found as enriched margarine. The use of "artificially" enriched spreads allows achieving recommended intakes.

A second observation from our study is that collective catering provides n-6 PUFA in excess. Therefore, with suboptimal n-3 intakes the n-6/n-3 PUFA ratio is well above recommendations as reportedly found in western diet (6,8). As seen with the in-hospital low-fat menu, to maintain n-6/to n-3 to acceptably low value (close to 4:1) both lowering n-6 PUFA and increasing n-3 PUFA must be favored.

Thirdly, FA and SFA contents were relatively high in collective municipal catering. Hospital catering provided them at lower levels and this is regarded as beneficial on metabolic parameters (38,39). By contrast, MUFA dietary contents were low in both studies. Such low levels have been correlated with adverse effects on metabolic homeostasis including insulin sensitivity (40,41).

Considering that insufficient n-3 PUFA supplies or excessive n-6/n-3 ratio during infancy was suggested to predispose to metabolic disorders in adulthood (42,43) and that n-3 PUFA from nutrition should be integrated in primary and secondary prevention of several low-grade inflammation-associated disorders (44-47), reaching adequate or recommended n-3 PUFA supplies and n-6/n-3 ratio in collective nutrition intended for sensitive populations (children, patients) is thus of major importance and still needs effective and applicable solutions. Strikingly, menus proposed to diabetic subjects in St Luc hospital presented higher n-6/n-3 ratio, owing to addition of dressings. Several aspects can be adressed in order to improve n-3 PUFA supplies. Those hold for collective catering as well as for nutrition in the general population. First of all, fish and oils rich in ALA (Flaxseed, Canola, Soybean, Walnut) represent the main and more accessible sources of n-3 PUFA in occident. Thus, the first effective measure for increasing n-3 PUFA intakes should consist in actively promoting fish consumption, in order to effectively reach, if not overtake, the recommended 35-40 g fish/d. An additional modification should consist in the use of ALA rich oils. For example, replacement of dressing oils rich in n-6 PUFA (mainly safflower oil in the present study) by oils rich in n-3 PUFA and poor in n-6 PUFA (flaxseeds, walnuts, wheat germ, rapeseeds, soybean) may provide a substantial additional supply in n-3 PUFA (15 g walnuts oil = 1.5 g ALA = 2 dressings) and a concomitent decrease in n-6 intake. As edible wild plants provide higher amounts of ALA and antioxidants than intensively cultivated plants (30), also reflected in milk from organic farming (48), encouraging agricultural methods that are more respectful of developmental cycles and natural nutritional contents of plants and animal products would help to increase n-3 PUFA consumption. Finally, n-3 PUFA are easily oxidized to deleterious trans-fats and free radicals by oxygen, light and heat, and cooking might reduce n-3 PUFA content of fish by up to 50% (49). This justifies promoting the consumption of freshly harvested raw (or cooked at low heat) fish and raw n-3 PUFA-rich oils.

The inclusion of n-3 PUFA enriched manufactured products may represent an alternative to compensate for insufficient supply of natural products. As seens in this study, the addition of 2 portions a day of n-3 PUFA enriched margarine (consumed at 90% as evaluated by the nursing staff) allowed to meet the recommended daily n-3 PUFA and EPA+DHA intakes. Indeed, food enrichment is emerging as perhaps the best long-term solution to the chronically-low intake of n-3 PUFA that plagues western cultures (32). Agrifood industry is developing products enriched in n-3 PUFA, most notably eggs, yogurt, milk and spreads, using n-3 PUFA rich feeding (50). Alternatively, n-3 PUFA synthesis might be induced by genetic manipulation aiming at enhancing either ALA or LC n-3 PUFA contents in derived oil. As a result, LC n-3 PUFA concentration amounting those found in native marine organisms have been achieved (51). At the experimental level, transfection in mice and pigs of *fads1*, encoding the enzyme catalysing the conversion of n-6 to n-3 PUFA which is absent in mammals, resulted in spontaneous enrichment of their lipids with n-3 PUFA (52,53). This might pave the way to genetic manipulation of cattle and poultry to produce n-3 PUFA-rich raw material, despite innumerable ethical, ecological, economical and cultural issues in need to be addressed prior to generalization of such experimental trials.

After analysis, we presented the data to the persons in charge of elaborating the menus, and propositions were formulated to ameliorate the current situation. Firstly, in school catering, we proposed to use rapeseeds oil (59% MUFA, 20% n-6, and 9% n-3) in replacement of safflower oil (20% MUFA, 64% n-6 and 0.2% n-3) in some salad dressings. Forecast calculations showed that this would reduce excessive n-6 PUFA intake and increase both MUFA and n-3 PUFA intakes as exemplified by the figures in table 3. However simple, this measure is very efficient. The agents from school catering confirmed that rapeseed-based dressings have been globally well accepted by the children. Secondly, in in-hospital catering, replacement of white fish by fatty fish in one serving, as well as the use of oils rich in n-3 PUFA as an alternative to dressings have been discussed in order to try to overtake minimum DRI for n-3 PUFA and reduce n-6/n-3 ratio (particularly in menus for diabetic subjects). However, such changes might represent a substantial financial constraint as foodstuffs rich in n-3 PUFA (fatty fish, oils) are more expansive than similar foodstuffs which do not contain high amounts of n-3 PUFA (white fish, safflower oil). In addition, n-3 rich products have different organoleptic properties and strong taste, and thus proper education is required as such modifications confront to education and acceptance by consumer. This is probably easier to integrate onto the developing palette of tastes during childhood.

Alternatively to the dietician-assisted "dietary recall" or "dietary diary" methods commonly used for evaluation of nutritional supplies in the general population, the approach used here was to analyze representative menus elaborated by dieticians for collective caterings. Providing that the proposed portions are effectively consumed, which has not been assessed in this study, it yields valid quantitative appraisal of fatty acids profile, allowing for comparison with nutritional recommendations. Considering that the caterings investigated here delivered from 900 to 9500 meal/d, this approach represents a valuable tool for evaluation of nutrition supplies in the general population, with possible discrimination between different conditions (age, health...). In addition, working in partnership with local dieticians helped evaluating and implementing concrete solutions to improve FA profile and n-3/n-6 PUFA ratio in menus. Thus, beside its interest for retrospective and prospective studies, this approach offers the valuable opportunity to modify or readjust the practice, with a benefice to a significant proportion of the population.

Globally, literature provides compelling evidence for the health benefits of n-3 PUFA consumption and low n-3/n-6 ratio not only on the MetS, cardiovascular risks and associated co-morbidities, but also on other conditions such as neuro-inflammatory and neuro-degenerative diseases (54,55). This evidence must be taken into consideration and efforts have to be made to promote n-3 PUFA consumption and to reduce SFA and n-6 PUFA to positively influence the n-6/n-3 ratio. Despite increasing awareness, our results highlight firstly that meeting the recommendations is still challenging in collective catering, and secondly that the analysis of menus provided by catering can represent a valuable tool for both evaluation and improvement of practice, notably for so called at-risk populations.

Acknowledgements

Studies on catering were realized in collaboration with the Township of Lille (France) and the St Luc hospital (Brussels, Belgium) in an approach to improve the quality of the diet provided. We are thankful to Ms Bahiya Aguenou, the dietician in charge in Lille, for her collaboration by providing menus and menu compositions. We also thank all the dietitians from the dietary department of St Luc university Hospital, Brussel (Belgium) and especially Mrs Anne Méan and Ms Perrine Debusscher, for supplying menus and factsheets, and for their enthusiasm. This work was supported by FRS-FNRS grants (N°3.4578.07 and M.IS : F.45.08.08), la Direction de la Recherche Scientifique de la Communauté Française de Belgique (ARC grant, 05/10-328), University FSR grants to I.L. O.M.C. and I.L. are FRS-FNRS post-doctoral researcher and reseach associated, respectively.

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