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Nutritional intakes of vegetarian populations in France

JCh Leblanc[1]*, H Yoon[1], A Kombadjian[2] and Ph Verger[3]

[1]*Institut National Agronomique Paris-Grignon, Laboratoire de Biologie et Nutrition Humaine, 16 rue Claude Bernard 75005 Paris, France;* [2]*Clinique du poids, 12 rue de Ponthieu, 75008 Paris, France; and* [3]*Institut National de la Recherche Agronomique, Direction Scientifique NHSA, 147 rue de l'Université 75007 Paris, France*

Objective: To assess food behaviour and determine nutritional intakes of various vegetarian populations in France.
Design: A five-day self-administered food record which was mailed to members of the three principal French vegetarian organisations.
Subjects: 145 subjects, aged 7–87 y; 94 classical vegetarians (19% of those contacted), 34 Hindu lactovegetarians (17% of those contacted) and 17 macrobiotic (34% of those contacted).
Setting: The survey was conducted between March 1997 and July 1997 in France.
Results: Vegetarianism in France is represented by three main classes of food behaviour: ovolactovegetarian (AAV), lactovegetarian (KRI) and macrobiotic (MMK). The geometric mean intakes ranged from 1952 kcal/d (KRI), 2051 kcal/d (MMK) to 2384 kcal/d (AAV) for males and from 1302 kcal/d (MMK), 1675 kcal/d (AAV) to 1804 kcal/d (KRI) for females, after adjusting for age and BMI. The energy consumption in the MMK group was significantly lower than that in the AAV ($P < 0.05$) and KRI groups ($P < 0.01$), respectively. A difference among groups was observed for females ($P = 0.0002$), but not for males. The MMK group consumed less lipid than the other two vegetarian groups, 46 g/d for men and 38 g/d for women *vs* 80 g/d for men and 61 g/d for women in the AAV group and 93 g/d for men and 81 g/d for women in the KRI group, respectively. Differences with AAV and MMK were statistically significant ($P < 0.001$ for men and women for both groups). Mean protein consumption ranged from 60 g/d (AAV), 64 g/d (KRI) to 77 g/d (MMK) for males and from 46 g/d (MMK), 50 g/d (AAV) to 58 g/d (KRI) for females. Mean carbohydrate intakes ranged from 247 g/d (AAV), 321 g/d (KRI) to 338 g/d (MMK) in males and from 209 g/d (MMK), 228 g/d (AAV) to 242 g/d (KRI) in females. There were no significant differences in protein and carbohydrate intakes between the groups. Median calcium intakes ranged from 758.2 mg/d (MMK), 863 mg/d (AAV) to 989.3 mg/d (KRI) for the men and from 500.8 mg/d (MMK), 863 mg/d (AAV) to 934 mg/d (KRI) for the women. In the men, there was no differences in daily calcium intakes between the three vegetarian groups. However, we found a significant difference for women ($P = 0.0041$). The women in the MMK group presented significantly lower daily calcium intakes than the women in the AAV ($P = 0.013$) and KRI ($P = 0.0032$) groups. The AAV and KRI groups consumed dairy products supplying respectively 36% and 53% for the men and 39% and 59% for the women of total calcium against 0% for men and women in the MMK group. Median iron intakes ranged between 12.5 mg/d (KRI), 13.2 mg/d (AAV) and 22.5 mg/d (MMK) for the men and between 11.2 mg/d (KRI), 14.6 mg/d (AAV) and 16.9 mg/d (MMK) for the women. MMK (men $P = 0.0172$ and women $P = 0.0131$) and AAV (only in men $P = 0.037$) groups consumed significantly higher quantities of iron than did the KRI group. The heme iron median intake in males and females of the three vegetarian groups was very low ($< 0.5\%$).

Overall, the female vegetarians consumed 58.1 (MMK), 109 (AAV) and 127.4 (KRI) mg of vitamin C per day and the males 76.3 (MMK), 150.4 (AAV) and 150.4 (KRI) mg per day. Median vitamin B9 intakes ranged from 247.5 μg/d (KRI), 312 μg/d (MMK) to 390.4 μg/d (AAV) for the men and from 188.3 μg/d (MMK), 266.9 μg/d (KRI) to 323.8 μg/d (AAV) for the women. Vitamin B12 consumption ranged from 0.2 μg/d (MMK), 1.5 μg/d (AAV) to 1.7 μg/d (KRI) in the women and from 0.6 μg/d (MMK) to 1.0 μg/d (AAV and KRI) in the men. No differences in consumption were observed in the males. On the other hand, the women in the MMK group consumed significantly less vitamin C and B12 than did the women in the AAV ($P = 0.0006$) and KRI ($P = 0.0396$) groups, while it was at the limit of significance for the females ($P = 0.0715$) for vitamin B9.

*Correspondence: JCh Leblanc, Institut National Agronomique Paris-Grignon, Laboratoire de Biologie et Nutrition Humaine, 16 rue Claude Bernard 75005 Paris, France.
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Reprints: JCh Leblanc, Institut National Agronomique Paris-Grignnon, Laboratoire de Biologie et Nutrition Humaine, 16 rue Claude Bernard 75005 Paris, France.
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Conclusion: Our results suggest that vegetarians have a better understanding of dietary requirements than does the general population. We observed that the more restrictive the vegetarian diet, the more likely were there to be deficiencies in minerals and vitamins, especially heme iron, diary calcium and vitamin B12 intakes. This was a particularly true for macrobiotic diets and especially for women, which represents a group at particular risk for mineral and vitamin deficiency.
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Descriptors: vegetarian; food behaviour; nutritional intakes; 5-day diet records
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Introduction

Food choice behaviour enables us to ingest what we need in order to avoid nutrition-related deficiencies and pathologies (Louis-Sylvestre, 1987). However, certain factors, such as food fads and restrictive diets, can complicate this physiological mechanism and have unfavorable consequences. The long history of voluntary deprivation of meat or vegetarianism (Ouédraogo, 1994; Ouédraogo, 1999) has given rise to a variety of dietary types; with or without milk and dairy products, eggs, fish.

Apart from health and nutrition policies, there is no information on the dietary behaviour of vegetarians in France. In many cases, authors have simply reported subjects' ideas on their diet (Beardsworth & Keil, 1992) or have speculated on the advantages or the disadvantages of different vegetarian diets and the food consumption of vegetarians and nutrient deficiencies in this population (Lepetit, 1985; Bindra & Gibson, 1986; Baudier *et al*, 1987). Some epidemiological studies have supported the belief in the 'health' value of vegetarian foods in showing a lower incidence of dementia (Giem *et al*, 1993), low standardized cancer morbidity ratio (Mills *et al*, 1994), and a lower concentration of contaminants in breast milk (Dagnelie *et al*, 1992). By contrast, one cohort study conducted on vegetarian and other health conscious people failed to evidence any reduction in mortality among vegetarians after 17 years of follow-up. Furthermore, no significant relationship has been found between meat consumption and cardiovascular disease (Key *et al*, 1996). A recent pooled analysis of this cohort with four other prospective studies showed that vegetarians had a 24% lower mortality from ischemic heart disease than did non-vegetarians, but has not established any associations of a vegetarian diet with other major causes of death (Key *et al*, 1998).

We do not know with any accuracy the proportion of the French population practicing different forms of vegetarianism. However, the number of people who report being vegetarian is on the increase and is estimated at 2–3% of the French population in the health nutrition barometer, (CFES, 1996). Nevertheless, food behaviour and nutritional intakes in this population are unknown.

The aims of the present study were: (1) to define the food intake patterns of vegetarians; and (2) to determine the nutritional intakes associated with various vegetarian practices. We also compared these nutritional intakes to Recommended Dietary Allowances (RDA) for the French population (Dupin *et al*, 1992).

Materials and methods

Population recruitment
The subjects were recruited between March 1997 and July 1997 from members of the principal French vegetarian organizations. For the classical vegetarians (ovolactovegetarian), we contacted the Association Alliance Vegetarienne (AAV), which is regarded as the national representative for the promotion of vegetarianism and has 500 members. Ninety-four questionnaires were returned to us (19%). For the Hindu (lactovegetarian) group, subjects were recruited in a Radha-Krishna temple. Two hundred questionnaires were distributed to subscribers of the journal of the Hare Krishna movement, of which 34 were returned giving a 17% response rate. For the macrobiotics (vegan), the school of Michio Kushi was contacted and 50 questionnaires were sent with a response rate of 34% (17 questionnaires).

Dietary data collection
Subjects filled in five-day self-administrated food records. The quantity of ingested foods was estimated by usual measures such as cups, dishes and spoons. A dietician converted this evaluation of food units into weights. We calculated ingested nutrient values using BALI-3 software, which contains food composition data provided by the CIQUAL (Centre Informatique sur la Qualité des Aliments), Foch Centre and food industries. A specific vegetarian food database, containing the composition of some common vegetarian recipes was also employed in this study. In the analysis of vitamin intakes, the food composition of the database provided information to 80% for vitamins B9, B12 and C. The results shown in Table 4 correspond to vitamin consumption derived from this database.

Statistical analysis
The dietary data was analyzed as follows:

(1) Description of the characteristics and the food behaviour according to the different vegetarian types.
(2) Intakes of calories, macronutrients, vitamins and minerals and proportion of energy provided by different types of meal.
(3) The nutritional values of each group were compared to the Recommended Daily Allowances (RDA) for the French population (Dupin *et al*, 1992). In addition, vegetarian consumption was compared with the results of a recent survey of the whole French population, ASPCC (Association Sucre/Produits Sucre, Communication-Consommation) survey (Crédoc, 1996; Hebel & Calamassi-Tran, 1998).

Data were compiled using SAS 6.11 software (Statistical Analytic System, Cary NC 27513) running on the UNIX

system. The validity of assumptions was checked by normal probability plots and Shapiro-Wilk and Bartlett tests. Since the distributions of energy and macronutrient consumption were markedly positively skewed, the natural logarithm of these variables was used in computations to increase normality. Energy and macronutrient consumptions were compared by Analyses of Variance by adjusting for confounding variables. The median test was used for vitamin and mineral intakes, with the Ryan-Eloit-Gabriel-Welsch test for multiple comparisons.

Results

General characteristics of the vegetarian population
The general characteristics of the population are presented in Table 1. The response rate of questionnaires were 94 (19%) for the Association Alliance Vegetarienne, 34 for the Hindu group (17%) and 17 for the macrobiotic vegetarians (34%). The study population comprised 78 women (54%) and 66 men (46%) with a mean age of 48 y (range 7–87 y). Body mass index (BMI; weight/height^2) ($\pm$s.d.) were 20.75 ($\pm$2.66) for the females and 21.65 ($\pm$3.11) for the males. No correlation was found between age and BMI, except for MMK in the males ($r = 0.87891$; $P = 0.0211$). Age and BMI distribution were significantly different in the three groups according to sex ($P = 0.0088$ and $P = 0.0311$ for age; $P = 0.0005$ and $P = 0.0388$ for BMI in males and females, respectively). However, these values were not different between the two sexes in the same group.

Subjects had been practising vegetarianism for 20–30 years. Most (89%) of the respondents took some physical activity for 0.5 to 1.5 hours a day. Their favorite activities were walking, cycling, gardening, yoga, gymnastics and tennis. Only 6% of vegetarians smoked and the smokers consumed on average 11 cigarettes per day.

Types of dietary behaviour in the principal vegetarian groups
The nine food behaviour types associated with vegetarianism are presented in Table 2. In the total vegetarian population, we found the following food consumption patterns: OLV (31%), LV (28%), M and PM (12%), POLV (10%), SV (10%) V (4%), NV (3%), OV (2%). Analysis of food consumption patterns showed the representative types for each vegetarian group: 45% of the classical vegetarians (AAV) were ovolactovegetarians. In the Hindu group (KRI), 85% were lactovegetarians, while 76% of the macrobiotics (MMK) had a pescomacrobiotic diet. From this food behaviour, the study could incorporate all the different food consumption patterns in the three major vegetarian groups. We excluded the non-vegetarian group (NV) from the nutritional analysis of vegetarians, although the characteristics of the population did not differ before and after exclusion ($P = 0.80$ for age; $P = 0.93$ for gender composition).

Nutritional analysis of the three vegetarian groups
The geometric means of energy and macronutrient consumptions and their confidence intervals for the vegetarian groups are listed in Table 3.

Energy intake For all the three groups, caloric intakes in males were higher than in females. The geometric mean intakes ranged from 1951 kcal/d to 2384 kcal/d for males and from 1302 kcal/d to 1803 kcal/d for females, after adjusting for age and BMI. The energy consumption in the macrobiotic group (MMK) was significantly lower than that in the other two groups ($P < 0.05$ compared with AAV and $P < 0.01$ with KRI, respectively). A difference among

Table 1 General characteristics of the study population

Group	*Sex*	*Age (y) Mean ± s.d. (Range)*	*BMI (kg/m^2) Mean ± s.d.*	*Starting age (y) Mean*
AAV ($n = 94$)	Male ($n = 37$)	50.38 ± 15.03 (28–86)	21.87 ± 2.39	28
	Female ($n = 57$)	52.56 ± 17.84 (22–87)	20.99 ± 2.65	
KRI ($n = 34$)	Male ($n = 24$)	41.70 ± 14.08 (11–72)	22.45 ± 3.37	18
	Female ($n = 10$)	37.33 ± 6.46 (26–48)	21.41 ± 1.80	
MMK ($n = 17$)	Male ($n = 6$)	31.17 ± 22.81 (7–59)	17.21 ± 2.81	29
	Female ($n = 11$)	45.91 ± 14.77 (12–70)	18.90 ± 2.76	

BMI: body mass index; AAV: Vegetarian Association Alliance; KRI: KRIshna; MMK: Macrobiotic Michio Kushi.

Table 2 Characteristics of the population consuming different types of vegetarian diet

	Number (%) of food behaviour in the considered group								
	NV	*SV*	*POLV*	*OLV*	*LV*	*OV*	*V*	*M*	*PM*
AAV ($n = 94$)	5 (5)	13 (14)	13 (14)	43 (45)	11 (12)	3 (3)	6 (6)	0	0
KRI ($n = 34$)	0	2 (6)	1 (3)	2 (6)	29 (85)	0	0	0	0
MMK ($n = 17$)	0	0	0	0	0	0	0	4 (24)	13 (76)

NV: Non-Vegetarian: Those who eat fish and meat at least once a week; SV: Semi-Vegetarian: Those who eat fish and meat once a week; POLV: Pesco-OvoLactoVegetarian: Those who do not eat meat but eat fish at least once a week; OLV: OvoLactoVegetarian: Those who do not eat meat and fish, but consume dairy products and eggs; LV: LactoVegetarian: Those who do not eat animal products, nor eggs; OV: OvoVegetarian: Those who do not eat meat, dairy products, but eat eggs; V: Vegetarian: Those who do not consume meat, dairy products, and eggs. They eat essentially fruit, vegetables and seeds; M: Macrobiotic: Those who do not consume meat, dairy products, and eggs, but eat the vegetables of the earth and the sea, seeds, soups and lactofermented products; PM: PescoMacrobiotic: Those who do not consume meat and dairy products, but eat white flesh fish once a week.

Table 3 Geometric means (95% confidence interval) of energy and macronutrient consumption

	Sex	*AAV (M = 34, F = 55) geometric mean (95%CI)*	*KRI (M = 24, F = 10) geometric mean (95%CI)*	*MMK (M = 6, F = 11) geometric mean (95%CI)*	*P*	*RDA*
Energy (Kcal/d)	Male[a]	1951.79 (1188.58–3642.50)	2384.55 (1302.32–3925.00)	2051.02 (937.80–3925.52)	NS	—
	Female[a]	1675.20 (1018.61–2747.60)	1803.74 (1247.98–2841.28)	1302.39 (689.35–2694.09)	***	
Protein (g/d)	Male[b]	59.62 (29.17–117.00)	64.37 (30.42–120.27)	77.06 (37.64–138.11)	NS	
(% energy ± s.d.)[c]		11.51 ± 2.39	10.96 ± 2.69	15.05 ± 0.91	**	12
	Female[b]	50.07 (25.75–106.02)	57.99 (31.81–105.13)	46.35 (25.73–98.89)	NS	
		12.85 ± 3.11	12.49 ± 2.65	14.85 ± 1.21	NS	
Carbohydrate (g/d)	Male[b]	246.49 (131.51–542.41)	321.35 (161.87–559.74)	338.14 (155.86–592.09)	NS	
(% energy ± s.d.)[c]		51.84 ± 7.38	53.54 ± 5.39	63.45 ± 4.23	***	30–35
	Female[b]	227.58 (129.36–368.78)	242.39 (130.63–438.93)	209.37 (94.75–452.01)	*	
		52.57 ± 6.20	51.24 ± 6.28	61.24 ± 8.26	***	
Lipid (g/d)	Male[b]	79.73 (46.62–146.05)	93.22 (49.52–158.35)	45.59 (15.35–131.77)	***	
(% energy ± s.d.)[c]		36.65 ± 7.83	35.50 ± 4.26	21.50 ± 4.45	***	50–55
	Female[b]	60.94 (33.26–120.20)	80.89 (47.95–116.87)	38.29 (11.38–99.94)	***	
		34.57 ± 6.04	36.27 ± 6.42	23.91 ± 8.48	***	

[a]Adjusted for age, BMI; [b]Adjusted for age, BMI, energy intake; [c]Contributing percentage to energy intake excluding alcohol. Non-adjusted values; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

groups was observed for females ($P = 0.0002$), but not for males.

Macronutrient intakes

- Protein Intake: Protein coonsumption was highest in males (77.06 g/d) and lowest in females (46.35 g/d) of the MMK group, but the differences between the three groups were not significant. It ranged from 59 g/d to 77 g/d for the males and from 46 g/d to 58 g/d for the females. Proteins contributed between 11% and 15% for men and 12% and 15% for women of whole energy intakes.
- Lipid Intake: The MMK group consumed less lipid than the other two vegetarian groups both in absolute amounts (46 g/d for men and 38 g/d for women) and as a percentage of total calories (21% for men and 24% for women, respectively). Differences with AAV and MMK were statistically significant ($P < 0.001$ for men and women for both groups).
- Carbohydrate Intake: Carbohydrate intakes ranged from 247 g/d to 338 g/d in the males and from 209 g/d to 242 g/d in the females. The energies as carbohydrates ranged from 51% to 63% according to gender and group. Significant differences were found for ingested amount and the percentage of whole energy, except for the absolute amounts consumed by the males.

Assignment of daily energy intake to diverse meals The mean caloric assignment to diverse meals was not significantly different between the three vegetarian groups. Breakfast supplied between 17% and 24%, lunch 35% to 38% and diner 25% to 34%. Snacks provided 11–16% of the total energy.

Alcohol consumption Alcohol consumptions were 5.7, 2.1, and 1.3 g/d for the AAV, KRI and MMK groups respectively.

Mineral consumption Table 4 shows the mineral intakes for the 5th, 50th and 90th percentiles in males and females of the three vegetarian groups.

Median calcium intakes ranged from 758.2 mg/d to 989.3 mg/d for the men and from 500.8 mg/d to 934 mg/d for the women. In the men, there was no differences in daily calcium intakes between the three vegetarian groups. However, we found a significant difference for women ($P = 0.0041$). The women in the MMK

Table 4 Mineral and vitamin intakes in the vegetarian populations

		AAV (M = 34, F = 55)			*KRI (M = 24, F = 10)*			*MMK (M = 6, F = 11)*				
Nutrients	*Sex*	*5th*	*Median*	*95th*	*5th*	*Median*	*95th*	*5th*	*Median*	*95th*	*P*	*RDA*
Ca (mg/day)	Male	400.34	862.87	1549.52	397.81	989.33	2031.10	386.39	758.24	953.50	NS	900
(%Animal Origin)		0	36.1	63.7	20.7	52.7	82.6	0	0	0	***	66
	Female	421.77	862.87	1549.52	687.15	934.05	1956.42	354.99	500.77	1087.27	**	900
		0	39.3	69.4	18.2	58.7	85.0	0	0	0	***	66
Fe (mg/day)	Male	9.25	13.19	22.98	8.65	12.48	19.22	15.17	22.55	32.84	*	10
(heme iron mg/day)		0	0.2	0.9	0	0	0.2	0	0.1	0.1	***	—
	Female	9.25	14.62	30.06	6.61	11.17	16.97	10.25	16.90	37.12	NS	18
		0	0.2	0.7	0	0	0.8	0	0	0.1	**	—
Mg (mg/day)	Male	254.64	371.67	725.80	226.85	371.79	525.94	352.35	655.93	801.93	NS	420
	Female	199.98	333.77	546.16	157.60	294.05	448.38	264.67	455.85	909.99	NS	330
Vitamin B9 (μg/day)	Male	192.68	390.36	1361.68	127.97	247.53	652.38	157.02	312.02	543.34	NS	300
	Female	178.72	323.83	638.30	133.25	266.94	733.18	106.03	188.35	406.10	NS	300
Vitamin B12 (μg/day)	Male	0	1.03	3.21	0.27	0.96	4.66	0.53	0.63	2.00	NS	3
	Female	0	1.45	6.42	0.57	1.73	8.34	0	0.19	1.83	*	3
Vitamin C (mg/day)	Male	21.05	150.44	532.88	37.95	127.83	233.38	37.37	76.30	143.10	NS	60–100
	Female	37.50	108.96	322.37	26.50	127.39	168.44	30.45	58.05	117.72	NS	60–100

5th = 5th percentile; 95th = 95th percentile; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

group presented significantly lower daily calcium intakes than the women in the AAV ($P = 0.013$) and KRI ($P = 0.0032$) groups.

Iron intakes ranged between 12.5 mg/d and 22.5 mg/d for the men and between 11.2 mg/d and 16.9 mg/d for the women. MMK (men $P = 0.0172$ and women $P = 0.0131$) and AAV (only in men $P = 0.037$) consumed significantly higher quantities of iron than did the KRI.

Vitamin consumption Table 4 shows the vitamin intakes for the 5th, 50th and 95th percentiles in males and females of the three vegetarian groups.

Overall, the female vegetarians consumed 58.1–127.4 mg of vitamin C per day and the males 76.3–150.4 mg per day. The women in the MMK group had a significantly lower consumption than did the women in the two other groups (58.1 mg/d *vs* 109.0 mg/d ($P = 0.0001$) for AAV, and 127.4 mg/d ($P = 0.0037$) for KRI).

Median vitamin B9 intakes ranged from 247.5 μg/d to 390.4 μg/d for the men and from 188.3 μg/d to 323.8 μg/d for the women. No differences in consumption were observed in the males, while it was at the limit of significance for the females ($P = 0.0715$).

Vitamin B12 consumption ranged from 0.2 μg/d to 1.7 μg/d in the women and from 0.6 μg/d to 1.0 μg/d in the men. The women in the MMK group consumed significantly less vitamin B12 than did the women in the AAV ($P = 0.0006$) and KRI ($P = 0.0396$) groups.

Discussion

The principle aims of all the vegetarian groups are physical and spiritual well-being. For some, vegetarianism represents an answer to the excess nutritional problems in rich countries, while for others it is a return to a more natural life. Whatever the motivation (e.g. religious, medical, ideological or spiritual), two major arguments underlie the various vegetarian doctrines: rejection of cruelty to animals and a crusade for health.

However, enumeration of the characteristics of different vegetarian groups shows that vegetarian practices cannot be simply defined as a voluntary deprivation of meat. For example, vegans also do not eat products of animal origin, as they are opposed to the stress-related conditions of much animal husbandry. The classical vegetarians, often represented as ovolactovegetarian, exclude meat and fish, but eat all vegetables, fruits, eggs, dairy products and honey. Their food selection is characterized by a refusal to consume slaughtered animals. A religious doctrine of the Hindus, another lactovegetarian group, is the conviction that animals have a common spiritual essence with human beings. They avoid meat, fish, eggs, and stimulants such as coffee, tea, alcohol and chocolate. Their meals are composed of fruits, seeds, vegetables and dairy products. Butter and cheese are considered as gifts from the God called Krsna in the Hindu religion. Another strict groups of vegetarians, the macrobiotics, have a diet based on 50–60% seeds, 20–25% vegetables grown according to 'organic' methods, and 10–20% soups or seaweed. Their choice of food and meal compositions is designed to maintain physiological levels of organic elements and minerals in the organism. The macrobiotic doctrine is based on the bipolarity of two opposing energies (Yang and Ying), inspired by Buddhist philosophy. Apart from the major vegetarian groups mentioned above, there are a variety of partially vegetarian groups. Vegetarianism was originally justified and recognized on moral and metaphysical grounds, but nowadays it may be also chosen for a variety of other reasons as well (Whorton, 1994).

Many developed countries (e.g. Germany, Switzerland, United Kingdom and USA) have national vegetarian societies, which federate regional societies or associations. In France, although there are a number of vegetarian associations, there is no organisation coordinating vegetarianism at a national level. We were thus able to incorporate vegetarian dietary practices independently of geographic distribution (urban and rural), of institutional attachment and philosophic affiliations in our study.

The dietary data on types of food consumed were found to be quite homogeneous in the Hindu and Macrobiotic groups but less so in the AAV group. Overall, nine different food consumption patterns were identified in this study. The low response rates in this study can be accounted for by members' concerns about the dissemination of incorrect information giving rise to a bad reputation for their dietary practices. The best response rate for the questionnaires was found in the 35–44-year-old group, which represented the majority of vegetarians in our population. Considering their mean starting age was around 30 y, we inferred that their vegetarianism was strongly self-motivated.

We compared our data to two reference values: (1) the Recommended Dietary Allowances (RDA) for the French population (Dupin *et al*, 1992), and (2) food and nutrient intakes of the French population from the ASPCC survey piloted by CREDOC (Centre de Recherche pour l'Etude et l'Observation des Conditions de vie) for the Observatoire des Consommations Alimentaire (Crédoc, 1996; Hebel & Calamassi-Tran, 1998).

Vegetarian energy intakes were lower than current dietary recommendations, but similar to those of the ASPCC survey. Proportions of macronutrients to total caloric intakes without alcohol closely resembled current recommendations for vegetarian groups rather than those for the general population. In common with other studies (Janelle & Barr, 1995; Tesar *et al*, 1992), we noted an increased energy as carbohydrate in our population. Absolute protein intakes appeared to cover RDAs (80 g/day for men and 60 g/day for women) and were comparable with published studies on vegetarianism. Major dietary protein sources were dairy products and cheeses for the AAV and KRI groups, and vegetarian foods (macrobiotics) for the MMK group. The macrobiotic foods were mostly derived from seeds (80%) and soy beans (20%).

Trends of increasing percentages of energy contribution from protein and lipid, found in some studies of the French population (ASPCC survey and Val de Marne study (Hebel & Calamassi-Tran, 1998; Hercberg *et al*, 1991) were not observed in our population. Alcohol consumption corresponded to 71, 26 and 16 ml of wine per day for the three groups respectively with a mean consumption of 4.2 g/day corresponding to 53 ml/day of wine.

The recommended calcium intake is 900 mg/day for the French adult population, with 66% from animal products origin; milk and dairy products. The AAV and KRI groups consumed the recommended amounts with dairy products supplying respectively 36% and 53% for the men and 39% and 59% for the women of total calcium. The main sources of calcium for these two groups were milk products and cheeses. However, the MMK group had an insufficient calcium intake. Even the 95th percentile of the calcium

consumption for the women was below the recommended intake (836.5 mg/day *vs* 900 mg/day). Moreover, their dietary calcium sources were almost exclusively from plant products, with no calcium foods of animal origin. The principal calcium sources were macrobiotic foods (41%), vegetables (21%) and legumes (14%). Calcium from certain plants containing oxalate (e.g. spinach, sorrel and rhubarb) or phytate (e.g. seeds and flour with bran) is not readily absorbable (Dupin *et al*, 1992; Guéguen *et al*, 1990). Among the different vegetarian populations, only the macrobiotics were liable to calcium deficiency due to low intake of calcium-containing foods and consumption of vegetables with poor calcium bioavailability. Lactovegetarian adults appear to meet recommended calcium intakes and do not present any reduction in bone density (Tesar *et al*, 1992; Weaver & Plawecki, 1994).

Total iron intakes of the vegetarian populations met RDAs (10 mg/day in males and 18 mg/day in females). The values were also comparable to the ASPCC data. Nevertheless, ferrous status cannot be estimated from total iron intakes. Hence iron, which is only found in foods of animal origin is better absorbed (25%) than non-heme iron (1–5%) (Dupin *et al*, 1992). While the absorption of non-heme iron depends on the nature of meals, that of heme iron is not influenced by other substances. Thus the bioavailability of ingested iron must be considered together with the existence of promoters or antagonists of non-heme iron absorption in foodstuffs. The heme iron intake in the vegetarian population was almost nil due to the extremely low consumption of animal products containing hemoglobin and myoglobin. Qualitative studies of iron intakes of vegetarian populations shows that more than 97% of their dietary iron sources are from plants. The main sources were vegetarian foods (14–50%), vegetables (11–16%), fruits (3–12%), bakery products (3–9%), seeds and pasta (11–16%) and legumes (6–10%). Proportion of heme iron was lower than 2% of their total iron intake. Problems of critical body iron stock levels have been noted in vegetarian children (Nathan *et al*, 1996), in young girls (Donovan & Gibson, 1995) and in adult vegetarians (Shaw *et al*, 1995; Bindra & Gibson, 1986) despite the fact that iron intakes did not differ from omnivorous populations. High prevalence of iron deficiency among vegetarians (particularly in women) may be attributed to low available iron intakes, concomitant with the higher intakes of dietary fiber, phytate and tannins, which inhibit non-heme iron absorption.

The current recommendations for magnesium intakes are between 330–420 mg/day. The intakes of our population attained this recommendation and appeared to be greater than that of the APSCC survey (on average 338 mg/day and 271 mg/day for men and women, respectively).

Vitamin B9 or folate intakes in the study satisfied the RDA (300 mgday for both sexes) and were above the ASPCC data (294 mg/day in men and 257 mg/day in women). In contrast, vitamin B12 or cobalamin intakes of our population below RDA (3 μg/d), with median consumptions of 0.3–1.0 mg/day in the males and 0.5–1.7 mg/day in the females. Only the AAV and KRI groups attained recommended intakes at the 95th percentile of consumption. The principal dietary sources of vitamin B12 were eggs, dairy products and cheese. Our observations are consistent with other published surveys (Dagnelie *et al*, 1994; Lentze, 1992), and the stricter the diet the more likely there was to be a nutritional deficiency. Lactovegetarian, lactoovovegetarian, and semivegetarian patterns are more likely to be satisfactory than vegan-like diets (Janelle & Barr, 1995; Jacobs & Dwyer, 1988; British Market Research Bureau, 1997). A decreased serum vitamin B12 has been observed with increased duration of vegetarianism (Tungtronhgchitr *et al*, 1993). The macrobiotic diet has been demonstrated to be a cause of nutritional deficiencies leading to impaired growth (Sanders & Reddy, 1994) accompanied by neurological (Specker, 1994) and psychomotor dysfunction (Dagnelie & van Staveren, 1994) in children. Metabolic disturbances have been observed in women and their children on macrobiotic diets (Gibson, 1994). Vitamin C intakes were above recommendations (60–100 mg/d) for all groups and for both sexes in our vegetarian populations. Compared to the ASPCC data, our vegetarians also consumed much more dietary vitamin C than did French men (78 μg/day) and women (74 μg/day) from the general populations. The principal dietary sources of vitamin C were fruits, fruit-based beverages, vegetables and dairy products.

Conclusions

Consumption of vitamin B12 was below the RDA for all three vegetarian groups in our population, and in the MMK group, calcium intakes were also below the RDA. For vegetarians, energy, protein, vitamins D and B12, calcium, zinc and iron are regarded as critical food-components (Lentze, 1992). Vegetarian diets contain lower amounts of protein, vitamin B12, calcium and higher amounts of carbohydrate, fiber, magnesium, ascorbic acid and energy as percent carbohydrate than do conventional human diets (Janelle & Barr, 1995; Tesar *et al*, 1992; Dagnelie & van Staveren, 1994).

The findings of the present study provided further support for a relation between the reduction in vitamin and mineral intakes with the strictness of vegetarian regimen. Lactovegetarian and lactoovovegetarian adults can potentially meet their dietary requirements of trace elements except iron (Gibson *et al*, 1997). Vegetarian diets are limited in bioavailable iron and so cannot maintain iron balance (Shaw *et al*, 1995). Other reviews have concluded that vegetarian diets can maintain iron balance if appropriate foods are chosen (Sanders, 1999). Nevertheless, in our study the vegetarian population, especially the vegan, are shown to be potentially at risk of calcium deficiency (Verger *et al*, 1999).

Elderly people, children, adolescents or pregnant women and those who practice strict vegetarian regimens in the long term are vulnerable to sub- optimal nutrients status. Suitable dietary recommendations for these target populations need to be devised along with a guide for appropriate vitamin and mineral supplements.

References

Baudier F, Chene D, Bourderont A, Abello C, Rosselet A & Mazelin A (1987): Enquête réalisée auprès d'une population 'semi- végétarienne': caractéristiques de leurs habitudes alimentaires. *Med. et Nutr.* **XXIII**, **6**, 385–390.

Beardsworth A & Keil T (1992): The vegetarian option: Varieties, Conversions, Motives and careers. *Socio. Rev.* **41**(2), 253–293.

Bindra GS & Gibson RS (1986): Iron status of predominantly lacto-ovo vegetarian East Indian immigrants to Canada. *Am. J. Clin. Nutr.* **44**, 643–652.

British Market Research Bureau (BMRB) (1997 February). *Dietary Survey*. *Vegetarians*. Food Safety Information Bulletin.

CFES (1996): French Education Committee for Health: *Health nutrition barometer of the French population*, p.32

Crédoc (1996): *Données de consommation individuelle française à partir de l'enquête ASPCC (Association Sucre/Produits Sucrés*, *Communication-Consommation)*. Note technique pour l'Observatoire des Consommations Alimentaires.

Dagnelie PC, van Staveren WA, Roos AH, Tuinstra LG & Burema J (1992): Nutrients and contaminants in human milk from mothers on macrobiotic and omnivorous diets. *Eur. J. Clin. Nutr.* **46**(5): 355–366.

Dagnelie PC, van Dusseldorp M, van Staveren WA & Hautvast JG (1994): Effects of macrobiotic diets linear growth in infants and children until 10 years of age. *Eur. J. Clin. Nutr.* **48**(Suppl 1), S103–S111; discussion S111–S112.

Dagnelie PC & van Staveren WA (1994): Macrobiotic and child health: results of a population based, mixed longitudinal cohort study in the Netherlands. *Am. J. Clin. Nutr.* **59**(5 Suppl), 1187S–1196S.

Donovan UM & Gibson RS (1995): Iron and zinc status of young women aged 14 to 19 years consuming omnivorous diets. *J. Am. Coll. Nutr.* **14**, 463–472.

Dupin H, Abraham H & Giachetti I (1992): Apports nutritionnels conseillés. *Tec-Doc Lavoisier*.

Gibson RS (1994): Content and bioavailability of trace elements in vegetarian diets. *Am. J. Clin. Nutr.* **59**(Suppl), 1223S–1232S.

Gibson RS, Donovan UM & Heath AL (1997): Dietary strategies to improve the iron and zinc nutriture of young women following a vegetarian diet. *Plant Foods Hum. Nutr.* **51**(1), 1–16.

Giem P, Beeson WL & Fraser GE (1993): The incidence of dementia and intake of animal products: preliminary findings from the Adventist Health study. *Neuroepidemiology* **12**(1), 28–36.

Guéguen L *et al* (1990): La biodisponibilité du calcium des aliments. *Cah. Nutr. Diet.* **25**, 233–236.

Hebel P & Calamassi-Tran G (1998): *Apports en vitamines et minéraux à partir de l'enqueête ASPCC (Association Sucre/Produits Sucrés*, *Communication-Consommation)*. Note Technique 98-21 du CREDOC pour l'Observatoire des Consommations Alimentaires.

Hercberg S, Preziosi P, Galan P, Deheeger M & Dupin H (1991): Dietary intake in a representative sample of the population of Val-de Marne: II. Supply of macronutrients. *Rev. Epidemiol. Santé Publique* **39**(3), 233–244.

Jacobs C & Dwyer JT (1988): Vegetarian children: Appropriate and inappropriate diets. *Am. J. Clin. Nutr.* **48**, 811–881.

Janelle KC & Barr SI (1995): Nutrient intakes and eating behavior scores of vegetarian and nonvegetarian women. *J. Am. Diet. Assoc.* **95**(2), 180–186.

Key TJ, Thorogood M, Appleby PN & Burr ML (1996): Dietary habits and mortality in 11,000 vegetarians and health conscious people: results of a 17 year follow up. *Br. Med. J.* **313**(7060), 775–779.

Key TJ, Fraser GE, Thorogood M, Appleby PN, Beral V, Reeves G, Burr M, Chang-Claude J, Frentzel-Beyme R, Kuzma JW, Mann J & McPherson K (1998): Mortality in vegetarians and non-vegetarians: a collaborative analysis of 8300 deaths among 76,000 men and women in five prospective studies. *Public Health Nutrition* **1**1, 33–41.

Lentze MJ (1992): Vegetarian and outsider diets in childhood. *Schweizerisch rundschau fur madizin praxis* **81**(9), 254–258.

Lepetit G (1985): Alimentation, motivations et comportement d'un groupe de végétariens français. *Cah. Nutr. Diet.* **XX**, **4**, 275–281.

Louis-Sylvestre J (1987): Adaptation de l'ingestion alimetaire aux dépenses énergétiques, Review. *Reprod. Nutr. Dévelop.* **27**(1B), 171–188.

Mills PK, Beeson WL, Phillips RL & Fraser GE (1994): Cancer incidence among California Seventh-Day Adventists, 1976–1982. *Am. J. Clin. Nutr.* **59**(Suppl 5), 1136S–1142S.

Nathan I, Hackett AF & Kirby S (1996): The dietary intake of a group of vegetarian children aged 7–11 years compared with matched omnivores. *Br. J. Med.* **75**(4), 533–544.

Ouédraogo AP (1994): Le végétarisme. Esquisse d'histoire social. *INRA*, *CORELA-HEDM*, September.

Ouédraogo AP (1999): La viande ou le salut. Genèse sociale du végétarisme occidental. *Annales* (in press).

Sanders TAB & Reddy S (1994): Vegetarian diets and children. *Am. J. Clin. Nutr.* **59**(Suppl 5), 1176S–1181S.

Sanders TAB (1999): The nutritional adequacy of plant-based diets. *Proceedings of the Nutrition Society* **58**, 265–269.

Shaw NN, Chin CJ & Pan WH (1995): A vegetarian diet rich in soybean products compromises iron status in young students. East Indian immigrants to Canada: a model approach. *Am. J. Clin. Nutr.* **125**(42), 212–219.

Specker BL (1994): Nutritional concerns of lactating women consuming vegetarian diets. *Am. J. Clin. Nutr.* **59**(5 Suppl), 1182S–1186S.

Tesar R, Novotelovitz M, Shim E, Kauwell G & Brown J (1992): Axial and peripheral bone density and nutrient intakes of postmenopausal vegetarian and omnivorous women. *Am. J. Clin. Nutr.* **56**, 699–704.

The French Education Committee for Health (1996): Barometer Health Nutrition.

Tungtronhgchitr R, Pongpaew P, Prayurahong B, Changbumrung S, Vudhivai N, Migasena P & Schelp F (1993): Vitamin B12, Folic acid and Haematological status of 132 Thai vegetarians. *Internat. J. Vit. Nutr. Res.* **63**, 201–207.

Verger Ph, Garnier-Sagne I & Leblanc J Ch (1999): Identification of risks groups for intake of food chemicals. *Regulatory Toxicology and Pharmacology* **30**, S103–S108.

Weaver CM & Plawecki KL (1994): Dietary calcium: adequacy of a vegetarian diet. *Am. J. Clin. Nutr.* **59**(Suppl 5), 1238S–1241S.

Whorton JC (1994): Historical development of vegetarianism. *Am. J. Clin. Nutr.* **59**(Suppl 5), 1103S–1109S.