Planning Well-Balanced Vegetarian Diets in Infants, Children, and Adolescents: The VegPlate Junior

VEGETARIAN DIETS, DEFINED as being devoid of flesh foods (such as meat, poultry, wild game, seafood, and their products), are followed by a growing number of people worldwide because of ethical, health, and environmental reasons.[1] Vegetarian diets include a variety of plant-based foods such as grains, legumes, nuts and seeds, fruits, and vegetables, and may or may not include dairy products and eggs. Vegan diets exclude all animal foods.

Although for over 30 years we have known that well-planned vegetarian diets, including vegan, are nutritionally adequate and promote regular growth from the early years of human development on,[2-4] some researchers still discourage parents from raising vegetarian children.[5,6]

This may be at least partially accounted for by the fact that children following very restrictive vegetarian patterns, which limit food choices and calorie intake, have been described.[7] These dietary patterns do not meet the criteria to be defined as well planned,[8] and therefore no conclusions about the growth of children following them should be made.

In Italy, 7.1% of the population follows a vegetarian diet (6.2% a lacto-ovo-vegetarian and 0.9% a vegan diet), a percentage that has nearly doubled in the last 5 years.[9] The exact number of vegetarian children is not known, but likely vegetarian parents would raise children following the same dietary pattern.

Various Vegetarian Food Guides have been proposed for adult vegetarians since 1997,[8] but so far none specifically for vegetarians aged 6 months to 17 years. Therefore, we designed the VegPlate Junior (VPJ), a Vegetarian Food Guide specific for dietary planning in infancy, childhood, and adolescence, and conceived to meet the Italian, as well as US, Dietary Reference Intakes (DRIs).[10,11] Diets obtained with the VPJ method meet all the criteria defining a vegetarian diet as "well-planned"[8] and are therefore suitable for promoting thriving and regular growth.

These criteria are:

- Including a wide variety of plant foods, such as grains, legumes and their derivatives, nuts and seeds, vegetables, and fruit. Dairy products and eggs are considered optional.
- Carefully choosing vegetable fats, consuming good sources of n-3 fatty acids, such as flaxseeds, chia seeds, and walnuts.
- Including reliable sources of calcium and paying attention to the status of both vitamin B-12 and vitamin D.

The aim of the VPJ is to help health care professionals in advising vegetarian parents, because parental education plays a central role in achieving optimal dietary patterns in vegetarian children.[12]

FOOD SELECTION

The VPJ is based on six food groups, plus two cross-sectional groups of calcium-rich foods and n-3-rich foods. Methods for food selection and serving size calculation have been described in detail in the VegPlate for adults.[13] For each food group, we selected the most representative plant foods from the Mediterranean tradition. Serving sizes for each item were calculated so that within the same group they would all be isocaloric, and they are the same as those in the VegPlate for adults.[13] The average nutritional composition of one serving from each group was then calculated and used to determine the daily number of servings to consume from each group to satisfy the Italian DRIs[10] from 1 to 17 years of age, for calorie requirements ranging from 800 to 3,600 kcal.

Other foods listed, such as dairy products, eggs, or meat analogs, are proposed as possible foods to consume but were not included in the calculations, and they can be consumed according to personal preference. For the different calorie requirements, from 1 to 17 years of age, the number of servings in each group necessary to reach nutritional adequacy is listed in Table 1.

GRAPHICS OF THE VPJ

The VPJ (Figure, A) is based on six food groups: grains, protein-rich foods, vegetables, fruits, nuts and seeds, and fats. The graphic draws attention to nutrients considered critical in vegetarian diets during all life stages: vitamin B-12 and vitamin D, located in the center of the plate, and calcium and n-3 fatty acids, whose food sources are represented as two cross-sectional groups. The basic graphic structure of the VPJ is the same as for adults,[13] given that the only adjustments performed were in the number of servings for each calorie range.

We also developed an adaptation of the VPJ for infants (Figure, B), to be used during complementary feeding (from approximately 6 months of age). The VPJ for infants recommends including the seventh food group of breastmilk (or infant formula) during complementary feeding.

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Table 1. Number of servings in the VegPlate Junior for children and adolescents (from 1 to 17 years of age)

kcal[a]	Grains	Protein-rich foods	Vegetables	Fruits	Nuts and seeds	Fats	Calcium-rich foods[b]	n-3—rich foods[cd]	Essential calories	Discretionary calories
800	3.5	1.0	1.0	1.0	1.0	3.0	3	2	802	0
900	3.5	1.0	1.0	1.5	1.0	4.0	3	2	879	21
1,000	4.5	1.0	1.5	1.5	1.0	4.0	3	2	986	14
1,100	5.5	1.0	1.5	1.5	1.0	4.0	3	2	1,081	19
1,200	6.0	1.0	3.0	1.5	1.0	4.0	4	2	1,162	38
1,300	6.0	1.0	3.0	2.0	1.5	4.0	4	2	1,272	28
1,400	6.0	2.0	3.0	2.0	1.5	4.0	4	2	1,364	36
1,500	6.5	2.0	4.0	2.0	1.5	5.0	5	2	1,480	20
1,600	7.5	2.0	4.0	2.0	1.5	5.0	5	2	1,575	25
1,700	7.5	2.0	4.0	2.5	2.0	5.0	5	2	1,685	15
1,800	8.0	2.0	5.0	2.5	2.0	5.0	5	2	1,755	45
1,900	9.0	2.0	5.0	2.5	2.0	5.0	5	2	1,850	50
2,000	9.0	3.0	6.0	2.5	2.0	5.0	5	2	1,965	35
2,100	9.5	3.0	6.0	3.0	2.0	6.0	5	2	2,090	10
2,200	9.5	3.0	6.0	3.0	2.5	6.0	5	2	2,167	33
2,300	10.5	3.0	6.0	3.0	2.5	6.0	5	2	2,263	37
2,400	10.5	3.0	6.0	3.5	3.0	6.0	5	2	2,372	28
2,500	11.5	3.0	6.0	3.5	3.0	6.0	5	2	2,468	32
2,600	11.5	3.0	6.0	4.0	3.0	7.0	5	2	2,545	55
2,700	12.5	3.0	6.0	4.0	3.0	7.0	5	2	2,640	60
2,800	13.5	3.0	6.0	4.0	3.0	7.0	5	2	2,735	65
2,900	14.0	3.0	6.0	4.5	3.0	7.0	5	2	2,815	85
3,000	15.0	3.0	6.0	4.5	3.0	7.0	—	2	2,910	90
3,100	15.5	3.0	6.0	4.5	3.0	8.0	—	2	3,003	97
3,200	16.0	3.0	6.0	5.0	3.0	8.0	—	2	3,083	117
3,300	16.5	3.0	6.0	5.0	3.0	9.0	—	2	3,175	125
3,400	17.0	3.0	6.0	5.0	3.0	10.0	—	2	3,268	132
3,500	17.0	3.0	6.0	5.5	3.5	10.0	—	2	3,378	122
3,600	17.0	3.0	6.0	5.5	4.0	10.0	—	2	3,455	145

[a]Energy requirements according to the Italian Dietary Reference Intakes[10]:

1-3 y: 800-1,500 kcal

4-6 y: 1,200-1,800 kcal

7-10 y: 1,500-2,500 kcal

11-14 y: 2,100-3,200 kcal

15-17 y: 2,400 kcal-3,600 kcal.

[b]This total number of servings must be consumed as calcium-rich foods from the other food groups.

[c]Of which at least one serving is flaxseed oil.

[d]The number of servings of the n-3—rich foods must be included in the total number of servings of nuts and seeds or fats.

USE OF THE VPJ

Infants

The VPJ adaptation for infants is meant to help vegetarian dietary planning from the beginning of complementary feeding. During this period of life, children experience extremely rapid growth,[14] for which a good nutritional status is essential. Because breast milk of vegetarian mothers is similar in composition to that of nonvegetarian mothers and thus nutritionally adequate,[3,4] the timing of the introduction of solid

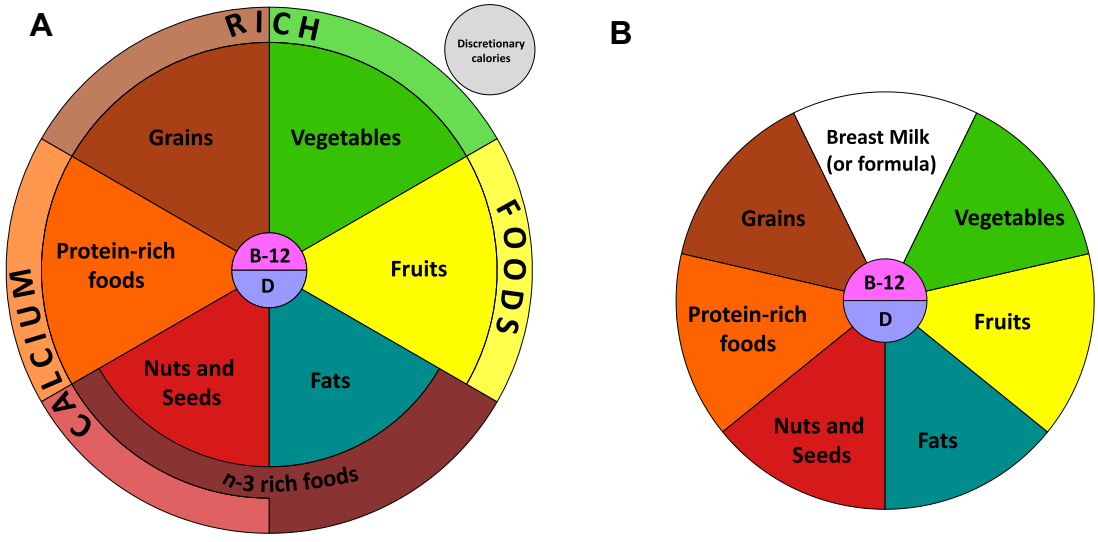

Figure. The VegPlate Junior.

foods should not differ from that of nonvegetarian children, that is, between 17 and 26 weeks.[5] Breast or formula milk should be continued until at least 1 year of age, because it provides a large amount of the daily requirements of energy, calcium, and n-3 fatty acids.[15]

In the first year of life, if the mother is not breastfeeding, the only alternatives are cow's milk infant formula and soy or rice formulas for vegan infants.[16,17] Nonformula soy and rice beverages lack important nutrients and should not be offered as breast or formula milk substitutes until at least 12 months of age.[16,17]

During complementary feeding, all solid foods from the VPJ are introduced in forms that do not constitute choking hazards (ie, nut butters instead of nuts),[5] with no particular rigid rule regarding the order of introduction.[16-18] To avoid early satiety, nutrient malabsorption, and poor growth, all of the offered foods to should be as low-fiber and as energy- and nutrient-dense as possible.[16,17] Main meals should be based on refined infant cereals, peeled beans, and nut and seed butters, and strained fruits and vegetables should be preferred.[16,17] Fruit should be offered as a snack, along with more nutritious foods such as breast milk or infant formula, cereals, yogurt, and nut and seed butters.[16,17] Dairy products and eggs from the protein-rich food group are considered optional, and they should be included in the diet according to parents' choices and beliefs. These recommendations apply also to meals or snacks offered to infants undergoing baby-led weaning.[19]

Cow's milk should not be introduced before 12 months of age because of its high protein and low iron content.[20] Fats are the primary source of energy for all infants and help vegetarian babies to easily reach their calorie requirements. Because fats play an important role in brain development, they should not be limited but carefully chosen to maintain an optimal n-3/n-6 ratio.[21-23]

For infants, the VPJ does not indicate the number of servings from each group to offer.

Breast or formula milk should continue on demand as usual until at least 1 year of age, and food from all groups should be offered daily at each meal or snack in the amount shown in Table 2.

Children and Adolescents

From 1 year of age, the growth rate slightly decreases, although it is still quite rapid until 24 months of age. After that, weight and height increase steadily until puberty, when a spike in growth velocity takes place.[14] The VPJ satisfies nutrient needs from 1 year to 17 years of age, as established by the Italian and US DRIs.[10,11] For different calorie requirements in the various age groups, the VPJ suggests the number of daily servings to consume for each

Table 2. Amount of food to offer to vegetarian infants at each main meal or snack

	6 mo	8 mo	12 mo
Instant infant cereal, refined grains or pasta	20 g	20-30 g	30 g
Beans (dry weight)	10 g	15 g	20 g
Tofu	10-20 g	10-20 g	20 g
Flaxseed oil/olive oil	5-10 g	5-10 g	5-10 g
Nuts and seeds butter	0-10 g	10 g	10 g
Fresh fruit	0-100 g	0-100 g	0-100 g
Plant-milks[a]	0-200 mL	0-250 mL	0-250 mL
Cheese	—	20 g	20 g
Egg	—	½ yolk	½ yolk

[a]Plant-milks should not replace breast or formula milk for infants up to 12 months of age but can be used as a liquid in food preparation.

Table 3. Energy content and nutrient composition of diets obtained with the VegPlate Junior for children and adolescents (from 1 to 17 years of age), compared with the Italian and the US Dietary Reference Intakes (DRIs)[a]

kcal Unit of measure	Carbohydrates (g)	Carbohydrates[a] (%)	Protein (g)	Protein[b] (%)	Fat (g)	Fat[c] (%)	Calcium[d] (mg)	Iron (mg)	Zinc (mg)	Thiamin (mg)	Riboflavin (mg)	Vitamin B-3[e] (mg)	Fiber (g)
800	99	50	28	14%	35	40	315	8	6	0.9	0.5	8.1	22
900	107	47	29	13%	40	40	332	9	6	1.0	0.6	8.4	23
1,000	128	51	32	13%	42	37	390	10	7	1.1	0.7	10.4	27
1,100	148	54	35	13%	42	35	419	11	7	1.3	0.7	12.0	29
1,200	163	54	40	13%	43	33	518	13	8	1.5	1.0	14.1	34
1,300	171	53	43	13%	51	35	556	15	9	1.6	1.0	14.5	38
1,400	181	52	52	15%	53	34	636	17	10	1.7	1.2	15.3	41
1,500	194	52	55	15%	59	35	706	18	11	1.9	1.3	16.9	45
1,600	214	54	58	15%	59	33	736	19	11	2.0	1.4	18.5	47
1,700	222	52	62	15%	67	35	774	20	12	2.1	1.4	19.0	51
1,800	236	52	65	15%	68	34	844	22	13	2.2	1.6	21	55
1,900	256	54	68	14%	68	32	874	23	14	2.4	1.6	22	57
2,000	269	54	79	16%	71	32	1,010	26	15	2.6	1.9	24	62
2,100	286	55	81	15%	77	33	1,041	27	16	2.7	2.0	25	65
2,200	287	52	84	15%	84	34	1,062	28	16	2.8	2.0	25	68
2,300	307	53	87	15%	85	33	1,092	28	17	2.9	2.1	27	70
2,400	315	52	90	15%	92	34	1,130	29	18	3.0	2.1	27	74
2,500	335	54	93	15%	93	33	1,160	30	19	3.2	2.1	29	77
2,600	342	53	94	14%	98	34	1,177	31	19	3.2	2.2	29	78
2,700	362	54	97	14%	99	33	1,206	31	19	3.3	2.2	31	80
2,800	382	55	99	14%	100	32	1,236	32	20	3.5	2.3	32	82
2,900	400	55	101	14%	100	31	1,268	33	21	3.6	2.3	33	85
3,000	420	56	104	14%	101	30	1,297	34	21	3.8	2.3	35	87
3,100	430	55	106	14%	107	31	1,312	34	21	3.8	2.4	36	88
3,200	447	56	108	13%	108	30	1,344	35	22	3.9	2.4	37	91
3,300	457	55	109	13%	113	31	1,359	35	22	4.0	2.4	38	92
3,400	467	55	110	13%	118	31	1,374	36	22	4.1	2.5	38	93
3,500	475	54	114	13%	126	32	1,412	37	24	4.2	2.5	39	97

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Table 3. Energy content and nutrient composition of diets obtained with the VegPlate Junior for children and adolescents (from 1 to 17 years of age), compared with the Italian and the US Dietary Reference Intakes (DRIs)[a] *(continued)*

kcal Unit of measure	Carbohydrates (g)	Carbohydrates[a] (%)	Protein (g)	Protein[b] (%)	Fat (g)	Fat[c] (%)	Calcium[d] (mg)	Iron (mg)	Zinc (mg)	Thiamin (mg)	Riboflavin (mg)	Vitamin B-3[e] (mg)	Fiber (g)
3,600	476	53	117	13%	133	33	1,433	38	24	4.2	2.5	39	100
Italian DRIs 1-3 y	—	45-60	14	—	—	35-40	700	8	5	0.4	0.5	7	12.6-16.7[f]
US DRIs 1-3 y	130	45-65	13	5 - 20	ND	30-40	700	7	3	0.5	0.5	6	19
Italian DRIs 4-17 y	—	40-60	19-62	—	—	20-35	1,000	11-18	6-12	0.5-1.2	0.6-1.6	8-18	12.6-16.7[f]
US DRIs 4-17 y	130	45-65	19-52	10 - 30	ND	25-35	1,300	10-15	3-11	0.6-1.2	0.6-1.3	8-16	25-38

[a,b,c]Calories from carbohydrates, protein, and fat, respectively, expressed as a percentage of total energy.
[d]Calcium content is underestimated, because it does not account for calcium in water and the recommended number of servings of calcium-rich foods.
[e]Niacin synthesized endogenously from tryptophan must be added to this value.
[f]For each 1,000 kcal consumed.

group, as shown in Table 1. The nutritional composition of diets obtained with the VPJ method is shown in Table 3.

For corresponding levels of energy, the daily number of servings differs from the VegPlate for adults,[13] because the nutritional needs of children and adolescence are particular.[10,11] Although discretionary calories do not contribute to attaining nutritional adequacy and can be consumed according to individual preference, children and adolescents should be discouraged from choosing sweetened beverages or processed foods.[24]

NUTRIENTS OF CONCERN: SPECIFIC RECOMMENDATIONS

Calcium and Vitamin D

Calcium, an essential mineral during growth when bone mass is expanding, can be a critical nutrient in those vegetarian children who do not consume dairy products.[4,25] For the calculations in the VPJ, only plant foods and no dairy products were taken into account. Calcium needs were met by including 3 to 5 servings daily of calcium-rich foods. Calcium-rich foods are the same as for the VegPlate for adults,[13] one serving providing approximately 125 mg calcium. Because variety within the same food group must be ensured, even lacto-ovo-vegetarians should derive most of their dietary calcium from plant foods.

Tap and mineral water are also reliable sources of highly bioavailable calcium (absorption fraction from 23.6% to 47.5%).[26] When the calorie requirements are above 3,000 kcal, counting calcium-rich foods servings is unnecessary, because the variety of the diet provides the required amount of calcium. Although calcium content of breast milk is little affected by maternal calcium intakes,[17] breastfeeding vegetarian women are encouraged to meet their calcium requirements.[13] Because vitamin D status mainly depends on sun exposure, all children living at high latitudes, regardless of the type of diet, are at risk for deficiency.[27]

Both breastfed and formula-fed infants up to 1 year of age should be supplemented daily with 400 UI vitamin D.[28] From 1 year of age, if sun exposure is not adequate, the VPJ suggests meeting

the DRI for vitamin D (600 UI)[10,11] through supplementation.[29]

n-3 Fatty Acids

From weaning on, n-3 fatty acids should represent 0.5% to 2% of total energy and provide 250 mg of eicosapentaenoic-docosaexaenoic acid daily.[10] The consumption of two servings of n-3–rich foods recommended in the VPJ provides on average 5.0 g alpha-linolenic acid and satisfies the above-mentioned conditions for all of the calorie ranges. The avoidance of n-6–rich oils (ie, sunflower oil, corn oil) and tropical oils maximizes the conversion of alpha-linolenic acid to eicosapentaenoic-docosaexaenoic acid, because it minimizes the n-6:n-3 ratio,[22,23,30] which ranges from 2.79 to 3.08 in the VPJ.

During complementary feeding, infants can generally meet their n-3 fatty acid requirements through breast or formula milk and the suggested servings of fats.[30] Breastfeeding women should heed the recommendation to include a DHA source in their diet.[13] According to the Italian DRIs, all children from 6 months up to 3 years of age should additionally consume a 100 mg/d of DHA, regardless of the type of diet.[10]

Vitamin B-12

All vegetarians, including those who consume dairy products and eggs, are at risk of developing B-12 deficiency.[31] Failure to meet requirements for vitamin B-12 can result in life-threatening conditions in children whose B-12 stores can be low.[32] Mothers should check their B-12 levels before conceiving and supplement vitamin B-12 throughout pregnancy and breastfeeding to guarantee an adequate intake to the infant.[4,33]

After the beginning of weaning, because the amount of breast or formula milk can be variable, B-12 should be supplemented in all vegetarian infants.[16,17] Because of the high variability of absorption attributable to different frequencies of intakes, to satisfy the DRIs by supplementation, the Italian Society of Human Nutrition suggests B-12 daily single doses from 5 μg in infants to 50 μg in adolescents.[4] These recommendations satisfy both the Italian and US DRIs.[10,11]

OTHER NUTRIENTS

Fiber

Vegetarian children show a higher intake of fiber compared with nonvegetarian peers and may in some cases exceed recommendations.[16,17,34] Excessive amounts of fiber trigger early satiety, may cause constipation, and may interfere with nutrient absorption (especially iron, calcium, and fats).[17]

Choosing refined grains, peeling beans, and straining fruits and vegetables are practices that effectively reduce the fiber content of the diet and should be pursued from 6 to 24 months of age, a period of rapid growth.[16,17]

Protein

Plants provide all of the essential amino acids, and protein requirements are usually met and even exceeded on a vegetarian diet providing sufficient energy from a variety of plant foods.[3] Animal-derived products are not necessary to attain protein requirements, and their consumption depends on the family habits. Because of the lower digestibility of plant proteins, some authors suggest increasing protein DRIs of vegetarian children by 10% to 15%,[4] a percentage that the VPJ surpasses for all age ranges (Table 3).

Combining complementary sources of protein at each meal is not necessary, but an advantage in consuming complementary proteins at intervals of less than 6 hours was shown in children younger than 2 years of age.[34] In everyday practice, young children eat often throughout the day, so combining protein sources is not necessary when the variety of plant foods in the diet is assured.

Iron

Iron deficiency is highly prevalent among all children, regardless of the type of diet.[35] Vegetarian, and especially vegan, children show iron intakes above recommended levels, as much as twice the intakes of nonvegetarian peers,[36] and have normal iron stores.[37] In vegetarian diets, all iron is in the non-heme form, which has lower bioavailability than the heme iron found in meat and fish products (1%-34% compared with 15%-35%), because of differences in absorption and the fiber and phytate content of plant foods.[38,39]

Vitamin C, beta-carotene, and organic acids positively influence non-heme iron absorption, as well as some cooking practices that reduce the phytate content of foods (ie, soaking, sprouting, grinding, sour leavening, fermentation).[17,38,39] Vegetarian parents should be aware of the iron-rich foods in vegetarian diets, such as whole grains, legumes, soy products, green leafy vegetables, and nuts and seeds, and of the practices enhancing its bioavailability. Iron-fortified infant cereals may be useful for maximizing the iron content of the diet in the first 2 years of life, when whole grains should be limited.[16]

Zinc

Zinc requirements are met in all diets obtained with the VPJ, but the overall diet bioavailability of zinc may be lower when compared with nonvegetarian diets because of the high content of fiber and phytate in vegetarian diets.[40] The previously mentioned practices that decrease the phytate content of the diet also enhance zinc absorption, and the daily inclusion of zinc-rich foods, such as legumes, nuts and seeds, and cheese for lacto-ovo-vegetarian children, maximizes zinc intakes.

Iodine

Vegetarian children and adolescents should not rely on seaweed to meet iodine requirements, because its high content might exceed recommendations and impair thyroid function,[41] along with possible arsenic contamination.[42] Iodine requirements[10,11] are met by using iodized salt or algal source supplements. Because the amount of iodine per gram of iodized salt varies among countries, a daily consumption of approximately 3.3 to 5 g for Italian children and adolescents (providing 100 to 150 μg of iodine)[13] and approximately 2 to 3.33 g for US children and adolescents (providing 95 to 155 mg of iodine)[43] is suggested. Infants from 6 to 12 months of age meet their iodine requirements through breast and formula milk, and no salt should be added to infants' food.[16]

SUMMARY

Well-balanced vegetarian diets planned with the VPJ, which include a wide variety of plant foods and reliable sources of vitamin B-12 and vitamin D, are an adequate option for infants,

children, and adolescents. Vegetarian diets, because of their favorable content of fiber and essential nutrients, have been shown to be protective against childhood and adolescence obesity,[44] as well as obesity-related diseases that may occur later in life.[2,3] Exposing children to a great variety of plant foods may promote healthful eating habits later in life.

In Italy, one of three children is either overweight or obese,[45] and Europe and the United States show similar percentages.[46] In this scenario, the VPJ can serve as a foundation for planning omnivorous diets rich in plant foods and protective against childhood obesity, simply by introducing some servings per week of nonvegetarian foods.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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