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Children and adults should avoid consuming animal products to reduce risk for chronic disease: NO

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ABSTRACT
Excessive attention to the animal versus plant binary food choice reflects society's moral views on eating right. To claim that avoidance of animal products is required to prevent chronic disease is not supported by evidence, makes little sense from an evolutionary perspective, and distracts policy makers from common-sense approaches to achieve adequate nutrition. Animal products provide highly bioavailable nutrients, some of which are not easily obtained from plants, and can play a key role in meeting the nutritional challenges of populations in both high- and low-income countries. This role goes beyond the need for protein and relates to vitamins, minerals, and numerous often-overlooked nutrients, such as long-chain fatty acids, taurine, and choline. Restrictive dietary prescriptions that exclude animal products complicate the quest for optimal nutrition by undermining dietary diversity and flexibility, and by introducing a dependency on fortification and supplementation. Thus, a vegan diet may put the general population at increased risk of poor nutrition, a problem of particular concern for those with special nutritional requirements. *Am J Clin Nutr* 2020;112:931–936.

Keywords: adequate essential nutrition, protein, micronutrients, nutritional needs, animal products

Main Argument (Leroy)

An evolutionary perspective argues against the need to eliminate animal-source foods

As with all animals, human nutritional requirements have been influenced by dietary composition throughout the evolution of our species (1). Reliance on substantial amounts of animal foods from both terrestrial and aquatic origin (marrow, organs, fat, meat, eggs, fish, and/or seafood) is characteristic of the human diet throughout the Pleistocene and more recent hunter-gatherers, which can—to some degree—serve as models for ancestral behavior (2). Depending on which resources are available within each habitat, the share of animal products in such diets (as a proportion of total energy) usually exceeds what is now consumed in the West, with only occasional incidences of chronic "diseases of modernity" (3). These evolutionary relationships have influenced our reproductive, digestive, and metabolic functions, fulfilling the nutritional requirements for the development of a large brain (1, 2). The consumption of (fermented) milk exerted an additional evolutionary influence since the Neolithic in populations with access to livestock. The relatively short time frame during which lactase persistence developed indicates that dairy provided strong nutritional benefits for crop-based and malnourished populations in need of protein and micronutrients. The fact that animal products have provided indispensable nutrition for at least 1.5 million years (1) is hard to reconcile with arguments for their exclusion from current diets (2, 4).

The intake of animal foods cannot be causally linked to the incidence of chronic diseases

Available epidemiological studies predominantly point toward neutral or protective associations for such animal foods as dairy, fish, and poultry (5–8). In contrast, various (but not all) observational studies have shown weak relative-risk estimates for high red- or processed-meat intake (i.e., amounts far exceeding 1 serving/d). However, the latter diminish with studies having a lower risk of bias (9) or when cross-cultural assessment is performed (4). In less-Westernized settings, associations tend to

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Abbreviations used: ALA, α-linolenic acid; DIAAS, Digestible Indispensable Amino Acid Score; GRADE, Grading of Recommendations Assessment, Development, and Evaluation.

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disappear or even invert, indicating strong effect modification and confounding by baseline nutritional status and healthy user bias. Regarding the latter, lifestyle characteristics of low versus high consumers of red and processed meats indicate likely bias among these associations in Western countries. Vegetarians differ from nonvegetarians with respect not only to the amount of meat consumed, but also to smoking, physical activity, alcohol consumption, and processed-food intake. Overall, evidence for a causal connection between red- or processed-meat intake and chronic diseases or mortality is inconsistent and inconclusive. Indeed, there is at most "low" to "very low" certainty evidence that higher intakes of red and processed meats result in small reductions in cancer mortality and incidence (10) or cardiometabolic outcomes and all-cause mortality (11). Similarly, there is little evidence that severe restriction of animal foods beyond a well-formulated omnivorous diet would reduce the prevalence of overweight and obesity (12).

Animal and human intervention studies of causal mechanisms typically address only short-term and intermediate surrogate outcomes, whereas markers of oxidative and inflammatory stress or cardiovascular risk fail to indicate harm (4, 13). While a modest increase in LDL cholesterol may occur, animal foods decrease apoB-to-apoA1 ratio, a strong marker of small, dense LDL particles and future cardiovascular disease. In a recent rigorous systematic review involving the use of Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria, the quality of evidence linking red and processed meats to potential adverse health outcomes was found to be "low" to "very low," and not sufficient to support recommendations to reduce their consumption (14).

Animal foods provide high-quality nutrition

Animal products are the best source of nutrient-rich food for children <2 y old (15), while also providing the general population with important nutrition. A key benefit of animal foods is their protein amount and anabolic superiority (8, 12, 16), an advantage that becomes evident with consideration of essential amino acids content and ileal digestibility. The "Digestible Indispensable Amino Acid Score" (DIAAS) for animal protein is usually $\geq$1, outperforming plant proteins (legumes: 0.6; cereals: 0.3–0.5) and only approximated by soy (0.8–0.9). With use of state-of-the-art DIAAS, rather than conventional protein scoring systems, nuts, seeds, tofu, and pulses cannot be considered good sources of dietary protein (17).

Animal foods also provide essential fatty acids, with distinct benefits related to the content of EPA and DHA. These long-chain omega-3 fatty acids, abundantly present in oily fish and some other animal foods, are critical for normal brain development in childhood, fertility, immunity, and general health. Their shorter-chain precursor, α-linolenic acid (ALA, 18:3n−3; available in plants), is poorly converted in vivo (5–10% for EPA, 1–5% for DHA) (16, 18). Thus, to achieve the equivalent of the commonly recommended 250 mg/d of EPA or DHA may require many grams of ALA daily, well above the consumption level of most Western vegetarians and vegans (19).

As with EPA and DHA, vitamin A is more efficiently obtained by direct intake from animal foods than from plant precursors. The biological value of the latter depends on the dose and species of the carotenoid, genetic and ethnic variability, and dietary context. Vegan diets are often low in fat, which further compromises absorption. For β-carotene, absorption varies between 5% and 65% and conversion between 4:1 to 28:1 (20). Other vitamins that may become problematic with restriction of animal foods include vitamin D, riboflavin, and niacin. Adequate supply of vitamin B-12 is of particular concern, as vegans have lower serum vitamin B-12 concentrations and, consequently, higher plasma homocysteine than omnivores (4, 12, 16). Whereas animal foods are excellent sources of vitamin B-12 (the Recommended Daily Intake can be delivered by a 100-g serving of beef, tuna, trout, or sardines), vegan diets require supplementation to avoid adverse psychiatric, neurological, and hematologic effects of deficiency. Moreover, supplementation and fortification are not always adequate to achieve sufficiency (4, 16). With the possible exception of some foods foreign to Western cuisine (e.g., the sea vegetable nori), dietary sources of vitamin B-12 are limited to animal products. Furthermore, vitamin K-2 found in animal products (e.g., egg yolks and dairy) may play a protective role for bone and cardiovascular health, beyond the effects associated with plant-associated vitamin K-1 (21).

Animal products provide highly bioavailable minerals (4, 8). Multiple servings of vegetables are often needed to match a single portion of animal food, a problem that may be exacerbated by the presence of antinutrients such as oxalates and phytates (16). For some key minerals, it may be impractical to obtain optimal intakes from plant foods (1, 16). For example, calcium, iron, and zinc are readily absorbed from dairy, fish with edible bones, and red meat; bioavailability of these critical minerals is characteristically lower from plant foods (12). For selenium, availability in crops depends strongly on the mineral status of the soil, whereas animal products vary to a much lesser degree in this regard. In addition, iodine status is often problematic in vegans and somewhat less so in vegetarians, with dairy being a good source (4).

Thus, a plant-based food-supply system would be dependent on fortification and supplementation to avoid risk of widespread micronutrient deficiencies (16). Furthermore, plant-based diets would also lack health benefits derived from the matrix of whole animal foods, beyond macro- and micronutrients (8). For instance, animal foods contain commonly overlooked bioactive components that promote neurological health, cognitive functions, antioxidant defenses, and muscle physiology (2, 4). Relative or absolute deficiencies of choline, carnosine, anserine, creatine, taurine, carnitine, and glutathione may occur with avoidance of animal products (2, 4, 16, 22).

Avoidance of animal-source foods undermines dietary robustness and causes unnecessary risk

Considering the important benefits of animal products as nutrient-dense foods and the absence of evidence for harm, their elimination from the diet comes with unnecessary risks (12). By omitting entire food groups, veganism is a highly restrictive approach that may undermine dietary robustness (4). According to a recent analysis, the greatest food-security challenge in 2050 will be the provision of nutrient-dense foods rather than adequacy of calories or carbohydrates (23). Many of the most problematic nutrients are optimally provided by animal products, including high-quality protein, calcium, iron, zinc, and vitamins A, D, and B-12 (23), as well as choline and DHA (22).

From an international perspective, a lack of access to animal foods can exacerbate malnutrition in vulnerable populations (15). Animal foods supply many nutrients that may be lacking in the cereal-based diets in low-income regions of Asia, Africa, and South America. Provision of meat, eggs, fish, or dairy to children is an effective way to reduce stunting and promote cognitive development (1, 8, 15, 24). But even in high-income populations, vegan diets require careful planning and supplementation to avoid major health problems (4, 16). The required nutritional knowledge, dietary discipline, culinary skills (e.g., proper processing of dried legumes), and resource availability are not consistently present in the general population. Even among the most sophisticated consumers, vegan diets may not be suitable for many people, especially children (24) and those unable to convert plant-derived precursors in sufficient amounts into their bioactive forms (as considered above). In fact, suboptimal nutrient concentrations have been frequently encountered among vegan and vegetarian populations—for instance, with respect to long-chain omega-3 fatty acids, iodine, and vitamin B-12 (4, 16). Concerningly, >90% of vegans and 70% of vegetarians were reportedly deficient in vitamin B-12 (compared with ∼1 in 10 omnivores), with use of the most sensitive diagnostics (25). Moreover, vegetarian and vegan mothers often have low long-chain omega-3 fatty acid and vitamin B-12 status (24, 26, 27), putting the health of their offspring at risk, as underscored by clinical case reports describing severe pathologies (4). Although harmful dietary practices can also be found among omnivore parents, failure to thrive and serious malnutrition syndromes appear to be more strongly linked to vegan and vegetarian upbringing (28), with implications to health later in life (29).

Conclusions

Rather than being portrayed as a cause of a public health crisis, animal products should be recognized as being at the forefront of the battle against malnutrition and diet-related disease, including cardiometabolic diseases. These foods are nutrient dense, highly satiating, and provide a basis for diets aiming to restore metabolic health and prevent age-related diseases (8, 12, 30).

The excessive focus of dietary discourse on animal versus plant foods in the prevention of chronic disease is poorly supported by scientific evidence, especially with regard to calls for the total elimination of animal products. The argument against animal foods is largely based on observational studies that lack the causal data required to inform policy interventions. On the contrary, animal products offer quality nutrition, components of which cannot be easily substituted by plants. Food policies that aim to minimize animal-food consumption will expose populations to unnecessary risk, especially in the face of projected global nutritional challenges. Such narrow approaches to human diets may cause harm and distract from greater dietary priorities that find common ground at both sides of the animal versus plant foods debate, such as the importance of avoiding excessive intakes of nutrient-poor, highly processed foods in globalizing foodscapes.

Refutation (Barnard)

Dr. Leroy has recounted several common myths that merit correction. The romantic notion that hunter-gatherers have been free of "diseases of modernity" was contradicted by the extensive atherosclerosis found in autopsies of Masai individuals (31) and in ancient Inuit remains (32). Meat ingestion clearly contributes to atherosclerosis.

The effect of diet on brain size is mere conjecture. Whales, elephants, and dolphins have larger brains than humans, as did Neanderthals; shrews have a greater brain-to-body-size ratio. Meat and saturated fat consumption is associated with accelerated cognitive decline, increased risk of Alzheimer disease, and brain atrophy.

While a genetic mutation fostering lactase persistence prevents lactose-induced diarrhea, evolution provided no protection against milk's longer-term hazards, notably prostate, breast, and ovarian cancer. In 2020, the Adventist Health Study-2 reported that women with the highest (compared with the lowest) milk consumption had a 50% higher risk of incident breast cancer (33).

The benefits of vegetarian and vegan diets are not attributable to differences in smoking, physical activity, or alcohol use. These and many other confounders have been controlled for in epidemiologic studies. Randomized trials confirm that avoiding animal products reduces body weight, blood pressure, and lipids. A 2015 meta-analysis showed that vegetarian diets lowered total and LDL cholesterol by 14 mg/dL (0.36 mmol/L) and 13 mg/dL (0.34 mmol/L), respectively (34).

The risks of elevated LDL-cholesterol concentrations caused by animal product ingestion are not mitigated by particle-size differences. LDL particles are atherogenic, regardless of particle size (35). In the Women's Health Study, higher concentrations of both small and large LDL particles significantly increased the HR for incident cardiovascular disease (36).

The cited meta-analyses of observational studies that had calculated the benefits of reducing meat consumption by 3 servings/wk were described by Dr. Leroy as discounting these benefits. They actually confirm them. One (10) predicted a reduction in cancer mortality by 7%. A similar reduction in processed meat would be expected to reduce esophageal (30%), colorectal (7%), and breast (10%) cancer incidence, and overall cancer mortality (8%). The second (11) predicted a reduction in cardiovascular mortality by 10%, stroke by 6%, myocardial infarction by 7%, and type 2 diabetes by 10%, all statistically significant. The effects of avoiding meat altogether would likely be much greater.

The characterization of the evidence against meat as being of "low" or "very low" certainty was based on the highly controversial GRADE system, which is not suited to evaluating nutrition studies. It mistakenly discounts even the most rigorous prospective studies and would similarly have discounted studies demonstrating passive smoking's dangers. The benefits of avoiding animal products have been amply demonstrated in both prospective studies and controlled trials.

The idea that malnourished populations have used animal products as a hedge against malnutrition or starvation provides no guidance for individuals seeking to improve their health. Even in populations with marginal nutrition, reliance on animal products is a disastrous strategy. As meat-eating increased in China between 1990 and 2016, cardiovascular disease prevalence doubled.

Protein requirements in children and adults are easily met by a diet of legumes, vegetables, grains, and fruits. According to the WHO, "Protein deficiency is almost always accompanied by inadequate energy intake...," meaning the problem is a lack of food, not a lack of meat (37).

Regarding fatty acids, the European Prospective Investigations into Cancer and Nutrition (EPIC)–Norfolk Study found that, while long-chain fatty acid intake was lower in vegans than in fish-eaters, plasma concentrations of long-chain fatty acids were remarkably similar, suggesting better conversion from precursor fatty acids in the vegan group.

Ingesting preformed vitamin A has no advantage; it has potential toxicity not seen with β-carotene and other carotenoids.

While meat and dairy products contain vitamin B-12, absorption is often poor due to gastric atrophy, medications, and other causes, leading to marginal vitamin B-12 status in $\sim$20% of elderly individuals. Fortification or supplementation is more effective and cheaper.

Dr. Leroy cites iodine as one of milk's helpful attributes. However, cows do not synthesize iodine or any other element. Iodine in milk comes from iodine-containing disinfectants used to clean contaminated udders and milking equipment and from supplements fed to cattle (38). Better (and cheaper) nutritional strategies are the use of iodized salt, which greatly reduced iodine deficiency in the United States, or the use of sea vegetables, as is common in Asia. These strategies avoid the saturated fat, cholesterol, sugars, estrogens, and cancer risk associated with milk.

Similarly, animals do not synthesize iron or calcium. They obtain them from plants, as humans do. Green leafy vegetables are particularly good sources of both. Iron intakes among vegetarians are typically similar to or even slightly higher than those of omnivores (39). There is no value—and there are significant risks—of excessive iron intake. The same is true for taurine (which promotes intestinal production of genotoxic hydrogen sulfide) and choline (which is prothrombotic and promotes trimethylamine N-oxide production).

Animal products lack dietary fiber, vitamin C, and complex carbohydrate. Overall nutrient intake on an omnivorous diet is inferior to that on a healthful vegan diet. In a 2008 study, adopting a vegan diet increased total vitamin A activity, β-carotene, vitamins K and C, folate, magnesium, and potassium, while reducing intake of saturated fat and cholesterol (40).

Dr. Leroy's citation of inadequate nutrition related to "vegetarian and vegan upbringing" had nothing to do with the adequacy of vegan diets. Rather, it described a 1970s Israeli religious group that limited breastfeeding to 3 mo and then used an improper infant formula. The answer is not meat or bovine milk; it is breast milk or formula. As noted by the Academy of Nutrition and Dietetics, "…appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits … for all stages of the life cycle."

To nourish a growing population, feeding plants to animals and then consuming their muscles, milk, or eggs is resource-intensive, adds unwanted cholesterol, saturated fat, and pathogenic microorganisms, and displaces healthful nutrients.

Rebuttal (Leroy)

Dr. Barnard's dismissal of the rareness of diseases of modernity in ancestral populations and the link between animal foods and *Homo sapiens*' cognitive development as "myths" and "romantic notions" was less unexpected than his reference to George Mann (31). Being a critic of the diet–heart hypothesis, Mann precisely described the Masai as almost free of cardiovascular disease, despite intimal thickening and high intakes of animal fat. Likewise, the authors reporting on Inuit mummies not only mentioned that atherosclerosis could as well have been due to indoor fires, but also that they remained agnostic about clinical outcomes, especially as cardiovascular deaths were rare among mid-20th century Inuit (32).

The rebuttal relies heavily on nutritional epidemiology of chronic disease. As practiced in the West, the latter mostly expresses responses to cultural norms of "eating right" rather than identifying diet–chronic disease relations (41). Its limitations have been mentioned; adjustment for isolated lifestyle factors (e.g., smoking) remains inadequate to correct for the full spectrum of confounders and biases. Dr. Barnard's interpretation of the Nutritional Recommendations (NutriRECS) studies misses the point; the merit of GRADE, described as "controversial" but officially endorsed by >100 organizations worldwide, is to relate associations to quality of evidence. Statistical significance as such is not a sufficient basis for causal interpretation and guideline formulation if the evidence is low quality. Epistemologically, there is no reason nutritional sciences should settle for lower standards.

Controlled trials may strengthen observation-driven hypotheses but, as argued above, this has not been the case for animal foods. Isolating LDL cholesterol from a broader view of disease risk factors is poorly informative. The evidence disagrees with the claim that LDL particle-size differences do not mitigate risk (42, 43); and the importance of triglycerides and other components of the metabolic syndrome should not be disregarded. If anything, associations between LDL cholesterol and mortality are of a protective nature for most elderly individuals (44), the group in which most deaths occur and for which animal foods are largely beneficial in view of healthy aging (4).

The assertion that reliance on animal foods would be a "disastrous strategy," even for populations with marginal nutrition that suffer from deficiencies and rampant stunting incidences in children, originates from a higher-income, urban, and Western-centric perspective (15). Even in the West, however, dietary restrictions driven by ideological choice (rather than income) often lead to malnourishment of infants, children, and adolescents [the list of clinical case reports is long, the pathologies severe (4, 24)]. The position paper on vegan diets by the Academy of Nutrition and Dietetics largely reflects the perspective of Seventh-Day Adventists (45) and has been contradicted by warnings issued by other authorities (e.g., the Belgian Royal Academy of Medicine and the Swiss Federal Commission for Nutrition).

Animals concentrate nutrients from plants, which make them very robust sources of nutrition. The various deficiencies at the population level in people not being able (or not willing) to access them attest to that (4). Neither the boosting of "complex carbohydrates" nor the restriction of animal fat and "unwanted" cholesterol will meet the nutritional challenges of mid-century. The provision of essential nutrition will.

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Center in Washington, DC—nonprofit organizations providing educational, research, and medical services related to nutrition, encouraging the use of low-fat, plant-based diets and discouraging the use of animal-derived, fatty, and sugary foods. He writes books and articles and gives lectures related to nutrition and health and has received royalties and honoraria from these sources. FL is a board member of various academic nonprofit organizations, including the Belgian Association for Meat Science and Technology (president), the Belgian Society for Food Microbiology (secretary), and the Belgian Nutrition Society. On a nonremunerated basis, he also has a seat in the scientific committee of the Institute Danone Belgium and the Advisory Commission for the "Protection of Geographical Denominations and Guaranteed Traditional Specialties for Agricultural Products and Foods" of the Ministry of the Brussels Capital Region.

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