SUPPLEMENT

Plant-Rich Dietary Patterns, Plant Foods and Nutrients, and Telomere Length

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ABSTRACT

The world's population is aging as a consequence of an increased global life expectancy. Identifying simple strategies to promote healthy aging (i.e., absence of major chronic diseases, preserved physical and cognitive functions, intact mental health, and good quality of life) have emerged as a major public health concern. Identifying biomarkers to better characterize the aging process is a research priority. Telomeres are repetitive DNA sequences at chromosome ends that prevent the loss of genomic DNA, protecting its physical integrity. Telomere length (TL) is considered a biomarker of aging: shorter telomeres are associated with a decreased life expectancy and increased rates of age-related chronic diseases. Telomere attrition has been shown to be accelerated by oxidative stress and inflammation. Since edible plants contain plenty of compounds with antioxidant and anti-inflammatory properties, it is plausible that their sustained consumption might help counteract telomere attrition. In this narrative review, we update evidence on the association between plant-rich dietary patterns and plant-based foods and TL. First, we summarize findings from observational studies on the association between TL and *1*) adherence to plant-rich dietary patterns (mainly, but not only, focused on the Mediterranean diet); *2*) consumption of seeds (mostly focused on nuts, grains, and coffee); and *3*) intake of carotenoids, one of the plant-derived bioactives most studied in health and disease. Second, we summarize the main randomized controlled trials evaluating the effect on TL of dietary interventions involving either plant-rich dietary patterns or plant foods. Even though evidence from trials is very limited, several observational studies have reinforced the suggestive benefits of adherence to the Mediterranean diet (a plant-rich dietary pattern), consumption of seeds (and its derivatives), and dietary intake of carotenoids on TL, which further supports the research benefits of plant-rich dietary patterns and plant foods to promote health and longevity. *Adv Nutr* 2019;10:S296–S303.

Keywords: aging, telomeres, Mediterranean diet, plant foods, seeds, carotenoids

Introduction

Aging population

Aging is characterized by a progressive loss of physiological integrity, leading to impaired function and increased risk of major chronic diseases including cancer, diabetes, cardiovascular disorders, and neurodegenerative diseases (1). The aging population is a global trend: most developed countries in the world are experiencing a growth in the number and proportion of older people in their population. The steady increase over time of human life expectancy has totally changed the paradigm: individuals want to live longer and healthier. In this context, identifying simple strategies to promote healthy aging, defined as the absence of major chronic diseases, preserved physical and cognitive functions, intact mental health, and good quality of life, have emerged as a major public health concern. Furthermore, the costs of a progressively aging population are becoming a huge healthcare burden and are expected to increase (2). Therefore, preventing, or at least delaying, the onset and progression of age-related diseases is of utmost importance in public health. To date, most available preventive strategies rely on lifestyle, with diet being of particular relevance.

Biomarkers of aging

Identifying biomarkers to better characterize the aging process is a priority for aging research, since they help to identify premature frailty at its earliest stage. Importantly, they also enable better characterization of evidence-based strategies to promote healthy aging, as they shorten the required time to test the efficacy of lifestyle interventions. López-Otín and colleagues (1) defined 9 tentative hallmarks of aging, which include genomic instability, telomere attrition, epigenetic alterations, loss of proteostasis, deregulated nutrient-sensing, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, and altered intercellular communication. Understanding their relative contribution

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to aging is of vital importance to identify potential targets to improve human health during aging, which can be used as potential biomarkers of aging.

According to the American Federation of Aging Research, biomarkers of aging must have the following characteristics: *1*) must predict the rate of aging and the onset of future age-related conditions and diseases (i.e., be a better predictor of lifespan than chronological age); *2*) must monitor a basic process that underlies the aging process, not disease effects; *3*) must be testable, robust, and safe, and if possible, universal and nonexpensive (such as blood tests and imaging techniques); and *4*) must work in humans and laboratory animals (so that it can be tested in animals before being validated in humans) (3). Even though several candidate biomarkers of aging have emerged over the past few decades none has proved universally suitable, or robust, for measuring or predicting the degree of aging at either population or individual levels (3–6).

Telomere length

As previously stated, telomere attrition was suggested as 1 of the 9 hallmarks of aging (1). Telomeres are repetitive DNA sequences (5′-TTAGGG-3′) located at the ends of eukaryotic chromosomes that allow cells to distinguish chromosome ends from double-strand breaks and thus protect chromosomes from end-to-end fusion, recombination, and degradation. Telomeres prevent the loss of genomic DNA at the ends of linear chromosomes and in turn protect their physical integrity (7, 8). Telomeres undergo attrition each time a somatic cell divides (9, 10). Telomere length (TL) is considered to be a biomarker of aging; shorter telomeres are associated with a decreased life expectancy and increased rates of developing age-related chronic diseases (11, 12). TL decreases with age and varies considerably among individuals. Moreover, telomere attrition is accelerated by oxidative stress and inflammation (13, 14). Studies suggest that telomere attrition is modifiable, as substantial variability exists in the rate of telomere shortening that is independent of chronological age (15). Therefore, variability of TL may be partially explained by lifestyle practices, including dietary patterns. Given that plant-based foods have well-known antioxidant and anti-inflammatory effects, and that TL is affected by both of these processes, there are fair grounds to believe that the consumption of plant-based foods might help to counteract telomere attrition. As accelerated telomere attrition may underlie many chronic diseases, identifying modifiable factors that affect telomere dynamics is of high relevance. In this narrative review, we will summarize current evidence on the consumption of edible plants and TL. Evidence from observational studies on the association between TL and adherence to plant-rich dietary patterns (mainly, but not only, focused on the Mediterranean diet, MedDiet), consumption of seeds (mostly focused on nuts, grains, and coffee), and intake of carotenoids (one of the plant-derived bioactives mostly studied in health and disease) will be summarized. Furthermore, we will outline the main randomized controlled trials (RCTs) evaluating the effect on TL of dietary interventions specifically related to either plant-rich dietary patterns or plant foods.

Current Status of Knowledge

In 2011, one of the first reviews on diet, nutrition, and TL was published (16). One of the main conclusions of this work was that many vegetable-derived compounds, such as folate, polyphenols, vitamin C and E, or curcumin, might prevent telomere attrition. Over recent years, scientific evidence on the association between nutrients or food bioactives, whole foods, or specific dietary patterns and TL has increased substantially. Despite its observational nature, most studies reinforced the notion of plant-based diets as an appealing tool to delay telomere shortening. Successive reviews on the topic have been recently published (17–19), even though none of them had a plant-centric approach. Here, we highlight and review some of the most relevant work on the association between TL and adherence to plant-rich dietary patterns, consumption of plant-based foods, and intake of carotenoids, as well as findings from RCTs investigating changes in TL after dietary interventions involving plant-rich dietary patterns or plant foods.

Observational studies on the association between adherence to plant-rich dietary patterns and TL

Traditional analyses in nutritional epidemiology typically examined diseases in relation to a single or a few nutrients or foods. Although this type of analysis has been quite valuable and has successfully identified food groups associated with chronic disease, it also has several conceptual limitations. People do not eat isolated foods and nutrients, but meals consisting of a variety of foods with complex combinations of nutrients that are likely to be synergistic. Nowadays, nutritional epidemiology is moving the focus of their analyses to examining dietary patterns instead of isolated foods or nutrients, since dietary patterns better capture the cumulative effects of the overall diet. This might be of particular relevance in relation to TL, since nutrients and other bioactive compounds supplied through edible plants act synergistically by affecting one or more different processes (i.e., oxidative stress, inflammation, telomerase activity, and DNA methylation), all related to telomere attrition (16). Evidence from epidemiological studies on

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Abbreviations used: MedDiet, Mediterranean diet; NHS, Nurses' Health Study; PREDIMED, PREvención con Dieta MEDiterranea; RCT, randomized controlled trial; TL, telomere length.

plant-rich dietary patterns and TL is still very limited. To the best of the authors' knowledge, there are no studies on this topic conducted in vegan or vegetarian populations. Results from observational studies (mainly cross-sectional) on the association between plant-rich dietary patterns and TL are presented below and summarized in **Table 1**.

Lee et al. (20) obtained subjective dietary data from middle-aged and older Korean adults and identified 2 major dietary patterns using factor analysis. The authors reported that those adhering to a prudent dietary pattern (characterized by a high intake of whole grains, legumes, vegetables, seafood, and seaweed) in the remote past (i.e., 10 y earlier) showed longer TL, whereas no significant associations were observed regarding adherence to the Western dietary pattern (characterized by the high consumption of refined grain, red or processed meat, and sweetened carbonated beverages) (20). In accordance with previous findings, Gong et al. (21), after collecting data from subjective reports and creating dietary patterns using principal component analyses, reported that Chinese women adhering to a "vegetable-rich" dietary pattern (i.e., high intake of fruits and vegetables, whole grains, nuts, tea, dairy products, and eggs) showed significantly longer telomeres than those adhering to the so-called "macho" pattern (mostly comprised of animal foods and alcohols), to the "traditional" pattern (i.e., rice, red meat, and pickled vegetables), or to the "high energy-density" pattern (i.e., sugar-sweetened beverages, wheat flour, and deep-fried foods) (21). Additionally, Karimi et al. (22), also working with dietary patterns obtained by factor analysis, recently reported a positive association between TL and adherence to the healthy (high consumption of whole grains, refined grains, dairy, and cereals) and traditional (increased consumption of fruits, vegetables, whole grains, fish, and dairy products) dietary patterns in a cross-sectional study of 300 healthy people, aged 25–40 y. A negative association was observed regarding adherence to the Western dietary pattern.

The traditional MedDiet, identified as the traditional dietary pattern found in Crete in the early 1960s, is characterized by a high intake of vegetables, fruits, nuts, legumes, and grains (mainly unrefined); a high intake of olive oil but a low intake of saturated lipids; a moderately high intake of fish; a low intake of dairy products, meat, and poultry; and a regular but moderate intake of alcohol (specifically wine with meals) (23). As we previously mentioned, a main feature of the MedDiet is the high intake of olive oil, grains, vegetables, fruits, legumes, and nuts (24, 25). Given that the MedDiet is a plant-based and antioxidant-rich dietary pattern, there has been substantial interest focused on whether long-term adherence to the MedDiet protects against telomere attrition. The first study that tested this hypothesis involved 217 Italian elders (mean age: 78 y, 47% women) (26), whose adherence to the MedDiet was evaluated by the MedDiet Score developed by Trichopoulou et al. (27). Participants with higher adherence to the MedDiet (score $\geq$6) showed statistically significant longer telomeres compared with those with lower adherence to the MedDiet (26). Similar findings were also presented in a much larger study, 4676 women aged 42–70 y from the Nurses' Health Study (NHS) in the US (28): greater adherence to the MedDiet was associated with longer telomeres after adjustment for potential confounders. The authors also evaluated the association between other dietary patterns and TL: a higher Alternative Healthy Eating Index (that is, healthy eating) showed a weak positive association with longer TL, but they found no statistically significant associations for the prudent or Western dietary patterns (28). In a cross-sectional study of 1743 individuals from a multi-ethnic American cohort (mean age: 78 y, 68% women) (29), it was shown that greater adherence to the MedDiet was associated with longer TL in whites, but not in African Americans and Hispanics. More recently, a cross-sectional study conducted in 520 participants from the PREvención con DIeta MEDiterranea (PREDIMED) study (mean age: 67 y, 55% women), reported that greater adherence to MedDiet (assessed by the PREDIMED 14-item score) was associated with longer TL in women, whereas the opposite was observed in men (30). Finally, no associations between TL and adherence to the MedDiet, nor diet quality scores, were found in 679 Australian elders (mean age: 63 y, 51% women) (31).

In conclusion, adherence to MedDiet, as assessed by specific scores, is associated with longer TL in many populations with different backgrounds. Differences observed between men and women are intriguing and deserve further research. Adherence to so-called "vegetable-rich", "prudent", or "healthy" dietary patterns (obtained using factor analysis from the food and nutrient intake data) are related to longer TL, a finding that has not been observed for Western-type dietary patterns.

Observational studies on the association between seeds and TL

The abundance of guanines in telomeric DNA repeats (5′-TTAGGG-3′) makes telomeres optimal targets for oxidative damage (32). This fostered interest on whether dietary intake of antioxidant-rich foods might help preserve TL. Seeds are paradigmatic antioxidant-rich foods. The outer layer of grains, pulses, and nuts is naturally enriched in compounds that promote seed longevity by preventing oxidation of plant DNA. Results from observational studies on the association between the consumption of seeds and TL are presented below and summarized in Table 1.

The association between the dietary consumption of nuts and TL has been extensively investigated. No significant associations were found in cross-sectional studies conducted in 2006 Chinese elders (33), in 300 men from Iran (22), and in 2 sub-studies from multi-ethnic American cohorts (29, 34). In contrast, a study conducted in 1958 Korean individuals, reported statistically significant associations between the higher consumption of nuts and legumes and longer TL (20). Furthermore, Tucker et al. reported, in the largest study to date involving 5582 men and women from the National Health and Nutrition Examination Survey (NHANES) cohort, that the consumption of nuts and other seeds was positively associated with TL (35).

TABLE 1 Summary of the main findings from the observational studies included in the present review assessing the associations between telomere length and specific dietary exposures

Study design	Country	Sample size	Telomere length assessment method	Dietary exposure	Association with telomere length	Reference
Cross-sectional	Korea	1958	qPCR (relative TL)	Dietary patterns: Adherence to prudent and Western dietary patterns	Prudent dietary pattern was positively associated with TL. No associations regarding adherence to a Western dietary pattern	Lee et al. (20)
	—	—	—	Specific food items (seeds)	Higher consumption of legumes, nuts, and seaweed were associated with longer TL	—
Cross-sectional	China	553	Southern blot-based assay: Terminal restriction fragments (absolute TL)	Dietary patterns: Adherence to vegetable-rich dietary pattern, "macho" pattern, "traditional" pattern, and "high energy-density" pattern	Greater adherence to a "vegetable-rich" dietary pattern was associated with longer telomeres in women. No significant associations in men	Gong et al. (21)
Cross-sectional	Iran	300	qPCR (relative TL)	Dietary patterns: Healthy dietary pattern, traditional dietary pattern, Western dietary pattern	A positive association was reported between TL and adherence to the healthy and traditional dietary pattern; whereas a negative association was observed regarding adherence to the Western dietary pattern	Karimi et al. (22)
	—	—	—	Specific food items (seeds)	Intake of whole grains, refined grains, fruits, and vegetables was associated with increased TL. No associations with the consumption of nuts and seeds	—
Cross-sectional	Italy	217	qPCR (relative TL)	Dietary patterns: Adherence to a Mediterranean diet	Participants with higher adherence to a Mediterranean diet have longer telomeres and higher telomerase activity compared with those with lower adherence	Boccardi et al. (26)
Cross-sectional	US	4676	qPCR (relative TL)	Dietary patterns: Adherence to the Mediterranean diet, Alternative Healthy Eating Index, prudent pattern, and Western pattern	Greater adherence to the Mediterranean diet was associated with longer telomeres, as well as a higher Alternative Healthy Eating Index. No associations for the prudent or Western dietary patterns	Crous-Bou et al. (28)
Cross-sectional	US	1743	qPCR (relative TL)	Dietary patterns: Adherence to the Mediterranean diet	Greater adherence to the Mediterranean diet was associated with longer TL in whites, but not in African Americans and Hispanics	Gu et al. (29)
	—	—	—	Specific food items (vegetables and seeds)	Vegetable consumption was associated with longer telomeres, whereas cereal consumption was associated with shorter telomeres	—
Cross-sectional	Spain	520	qPCR (relative TL)	Dietary patterns: Adherence to the Mediterranean diet	Greater adherence to the Mediterranean diet was associated with longer telomeres only in women, whereas the opposite was observed in men	García-Calzón et al. (30)
Cross-sectional	Australia	679	qPCR (relative TL)	Dietary patterns: Dietary Guideline Index, Recommended Food Score, and Mediterranean Diet Score	No associations between Mediterranean diet adherence, nor diet quality scores and TL	Milte et al. (31)
Cross-sectional	China	2006	qPCR (relative TL)	Specific food items (seeds)	No associations between the consumption of legumes, seeds, and nuts, and TL	Chan et al. (33)
Cross-sectional	US	840	qPCR (relative TL)	Specific food items (seeds)	No associations between TL and intake of whole grains, fruit and vegetables, nuts or seeds, and coffee	Nettleton et al. (34)
Cross-sectional	US	5582	qPCR (relative TL)	Specific food items (seeds)	Nut and seed intake was positively associated with TL	Tucker (35)

(*Continued*)

TABLE 1 (*Continued*)

Study design	Country	Sample size	Telomere length assessment method	Dietary exposure	Association with telomere length	Reference
Cross-sectional	Italy	56	Southern blot-based assay: Terminal restriction fragments (absolute TL)	Specific food items (seeds)	No associations between TL and the intake of vegetables and cereals	Marcon et al. (36)
	—	—	—	Specific nutrients (carotenoids)	Positive correlation between TL and self-reported intake of β-carotene	—
Cross-sectional	US	2284	qPCR (relative TL)	Specific food items (seeds)	Cereal fiber intake was positively associated with TL	Cassidy et al. (37)
Cross-sectional	US	4780	qPCR (relative TL)	Specific food items (seeds)	Higher total coffee consumption was significantly associated with longer telomeres	Liu et al. (38)
Cross-sectional	US	5826	qPCR (relative TL)	Specific food items (seeds)	Coffee intake was positively related to TL, whereas caffeine consumption was inversely related to TL	Tucker (39)
Cross-sectional	US	7827	qPCR (relative TL)	Specific food items (seeds)	Negative association between caffeine intake and TL	Mazidi et al. (40)
Cross-sectional	US	586	qPCR (relative TL)	Specific nutrients (carotenoids)	Higher dietary intake of β-carotene was associated with longer TL	Xu et al. (41)
Cross-sectional	Australia	786	qPCR (relative TL)	Specific nutrients (carotenoids)	Higher concentrations of circulating carotenoids in the plasma (lutein and zeaxanthin) were associated with longer TL	Sen et al. (42)
Cross-sectional	US	3660	qPCR (relative TL)	Specific nutrients (carotenoids)	Higher concentration of circulating carotenoids (α-carotene, β-carotene, and β-cryptoxanthin) was associated with longer telomeres	Min and Min (43)
Cross-sectional	US	4018	qPCR (relative TL)	Specific nutrients (carotenoids)	Serum carotenoids were generally positively associated with TL	Nomura et al. (44)

The link between cereals and TL is less firmly established. Most cross-sectional studies report either null (33, 36), or even inverse associations (29), which is in apparent conflict with the notion of consumption of grains as a tool to prevent telomere shortening. Such inconsistent findings could be explained by a high intake of refined flour cereals, deprived of fiber and antioxidants contained in the outer layer of the grain, which is lost during the refining process. In accordance with this, the intake of cereal fiber, mostly supplied by the outer layer of the grain, was found to be positively associated with TL in a large observational study (37). However, when refined and whole-grain cereals are analyzed separately, both items have been found to be associated with TL (22).

Coffee, one of the most widely consumed sources of antioxidants, has also attracted increasing interest in relation to TL. Even though no significant associations between coffee intake and TL were observed in a cross-sectional study conducted in Americans (34), more recent studies portrayed an encouraging landscape for coffee-derived products. Positive associations between coffee drinking and TL have been reported in the context of the NHS (38) and NHANES (39) cohorts. However, when investigating caffeine as exposure, the opposite was observed: caffeine intake was inversely related to TL (38–40), which might be explained by the increasing contribution of sodas and energy drinks (both reputedly unhealthy foods) to total dietary caffeine intake in the average American diet.

In conclusion, there is abundant observational evidence regarding the positive associations between the long-term consumption of nuts, unrefined grains, and coffee and longer TL.

Observational studies on the association between carotenoids and TL

Besides nutrients, plants contain an array of bioactives and their sustained intake has long been related to health benefits. Carotenoids, which cannot be synthesized by animals, are potent lipid-based antioxidants (45) that contribute to the benefits ascribed to the consumption of their main dietary sources (green leafy vegetables and colored fruits). Therefore, carotenoids are one of the most studied phytochemicals in relation to TL. Results from observational studies on the association between TL and carotenoid intake are presented below and summarized in Table 1.

A small cross-sectional study evaluating dietary carotenoid intake by subjective reports showed a significant positive correlation between TL and self-reported intake of β-carotene (36), a finding reproduced in a larger population abstaining from multivitamin use (41).

TABLE 2 Summary of the main findings from the randomized controlled trials included in the present review assessing the effect of plant-based food interventions on telomere length

Study design	Country	Sample size	Telomere length assessment method	Intervention	Duration	Control diet	Association with telomere length	Reference
Parallel-group	Spain	520	qPCR (relative TL)	Mediterranean diet supplemented with extra-virgin olive oil and Mediterranean diet supplemented with mixed nuts	5 y	Low-fat diet	Participants on the Mediterranean diet supplemented with nuts showed a higher risk of telomere attrition compared with the control group	García-Calzón et al. (30)
Parallel-group	US	29	qPCR (relative TL)	Consumption of foods that included cooked navy bean powder and heat-stabilized rice bran	4 wk	Consumption of foods with no additional ingredient	No differences in TL were observed between groups	Borresen et al. (46)
Parallel-group	Spain	149	Quantitative fluorescence in situ hybridization (absolute)	Walnuts	2 y	Prestudy habitual diet (abstaining from walnuts)	Time × intervention interaction nearly significant ($P = 0.079$), suggestive of a trend of walnut consumption in preserving TL	Freitas-Simoes et al. (47)

Circulating carotenoids in blood, as objective markers of dietary intake, have also attracted substantial attention over recent years. In a population of 786 Australian elders, higher concentrations of carotenoids in plasma (lutein and zeaxanthin) were associated with longer TL (42). In a subset of 3660 participants from the NHANES cohort, a significant association between TL and the sum of α-carotene, β-carotene, and β-cryptoxanthin was observed (43): higher concentrations of blood carotenoids were associated with longer telomeres. This result was reproduced in a larger setting of the same cohort where serum carotenoids were generally positively associated with TL (44).

In conclusion, increasing dietary carotenoids, assessed by either subjective records or objective (circulating) biomarkers of exposure, directly relate to longer TL.

RCTs

To date, RCTs assessing the effect of plant-based food interventions on TL are very limited. **Table 2** summarizes the main findings from RCTs assessing the associations between TL and specific dietary interventions. In 2016, an RCT was conducted in the framework of the PREDIMED study: 520 participants (aged 55–80 y) from the PREDIMED-NAVARRA trial were randomly assigned to receive advice either to follow a low-fat diet (control group), to follow a MedDiet, which was supplemented with extra-virgin olive oil (1 L/wk), or to follow a MedDiet, which was supplemented with 30 g/d of mixed nuts (15 g walnuts, 7.5 g hazelnuts, and 7.5 g almonds). Interestingly, after 5 y of follow-up, participants allocated to the group adhering to MedDiet supplemented with mixed nuts displayed a higher risk of telomere attrition compared with the control group (30).

Regarding interventions exclusively with plant-based foods, within a very small RCT (29 participants) designed to determine the feasibility of increasing the dietary intake of navy bean and heat-stabilized rice bran (35 and 30 g/d, respectively) in colorectal cancer survivors, no significant differences in TL were observed between individuals consuming navy bean and rice bran compared with control subjects (usual diet) after a 4-wk intervention (46). To the best of our knowledge, only 1 RCT directly evaluated the effect of a whole food on telomere attrition (47). Authors investigated whether the inclusion of walnuts (15% of energy) in the diet for 2 years would maintain TL in cognitively healthy elders (63–79 y) compared with a control group (prestudy habitual diet, abstaining from walnuts). In this opportunistic study, authors reported a nearly significant ($P = 0.079$) interaction between time (baseline compared with 2 y) and dietary intervention (control compared with walnuts), suggestive of a potential effect of walnut consumption in preventing telomere attrition, to be confirmed in trials with adequate statistical power. Differences between these findings and results showed by the PREDIMED-NAVARRA trial could be partially explained by differences in the background of studied populations, specifically, the age range, the burden of CVD risk factors, and the nutritional background of the participants.

In summary, the limited evidence, coupled with controversial findings in trials involving nut supplementation, highlights the need for new, adequately powered RCTs.

Conclusions

The growing number of articles published on diet and TL over recent years confirms the increasing interest in dietary antiaging properties. Given that there is an existing link between oxidative stress and telomere attrition, it is plausible that consuming antioxidant-rich foods, for which edible plants are particularly well suited, may have important health benefits by helping to counteract telomere attrition. Data showing beneficial effects of plant-rich dietary patterns and plant foods mostly come from cross-sectional studies, and to the best of the authors' knowledge, no studies have been conducted in vegan or vegetarian populations. RCTs with adequate statistical power are needed to ascertain not

only whether TL can be modified through the consumption of plants, but also how this translates into primary prevention against age-related diseases and premature aging. Meanwhile, there is a compelling body of evidence to recommend regular inclusion of edible plants in the diet as a universal, cheap, and safe tool to obtain significant health benefits.

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