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# “Planeterranea”: An attempt to broaden the beneficial effects of the Mediterranean diet worldwide

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Non-communicable diseases (NCDs) lead to a dramatic burden on morbidity and mortality worldwide. Diet is a modifiable risk factor for NCDs, with Mediterranean Diet (MD) being one of the most effective dietary strategies to reduce diabetes, cardiovascular diseases, and cancer. Nevertheless, MD transferability to non-Mediterranean is challenging and requires a shared path between the scientific community and stakeholders. Therefore, the UNESCO Chair on Health Education and Sustainable Development is fostering a research project—“Planeterranea”—aiming to identify a healthy dietary pattern based on food products available in the different areas of the world with the nutritional properties of MD. This review aimed to collect information about eating habits and native crops in 5 macro-areas (North America, Latin America, Africa, Asia, and Australia). The information was used to develop specific “nutritional pyramids” based on the foods available in the macro-areas presenting the same nutritional properties and health benefits of MD.

## KEYWORDS

**Mediterranean diet, health, sustainability, local foods, nutritional properties, bioactive compounds, nutritional pyramid**

## Introduction

Non-communicable diseases (NCDs) account for more than 70% of global mortality (1). A recent report from the Global Burden Disease Study reported that almost 400 million people are suffering from diabetes (2) and the presence of diabetes is associated with increased mortality from infections, cardiovascular disease (CVD), and cancer (2, 3). Other to diabetes, high systolic blood pressure and high low-density lipoprotein cholesterol levels have been appointed as major contributors to the onset of CVD (54.6 and 46.6%, respectively) (4). Noteworthy, a 26.3% increase in new cases of cancer (mainly breast and gastrointestinal cancers) has been reported recently (5).

Given the epidemic of NCDs with increasing trends in high and middle-income countries and in adolescents/young adults (6, 7), the World Health Organization demanded for effective strategies to treat and prevent NCDs. In addition to lifestyle factors such as physical inactivity, smoking, alcohol intake, also diet has been established as highly modifiable risk factors for NCDs. Indeed, more than 9.1 million premature deaths from CVDs worldwide are attributable to dietary risks, regardless of age, sex, and sociodemographic development of the native country (8). As for cancer (breast and gastrointestinal cancers), nutritional inadequacy, and excess body weight (overweight and obesity) lead to a significant increase in cancer incidence during the last decades (9, 10).

Different dietary approaches have been proposed for the prevention and treatment of NCDs. Among this, Mediterranean diet (MD) have been associated with body weight control (11, 12) and reduced risk for chronic diseases, including CVD (13, 14), type 2 diabetes (T2D) (15), and some cancers (16–20).

Moreover, MD has shown a protective role also for immune-related diseases such as atopy and asthma (21, 22).

These beneficial effects are related to the nutritional composition of MD that can be obtained through the combination of some foods with a specific frequency of consumption during the week (23): (a) regular consumption of plant-based foods (fruits, vegetables, wholegrain, legumes, and nuts), and extra-virgin olive oil as the primary source of fat; (b) moderate amount of animal protein and fat, with fish and low-fat dairies as the preferred sources, respectively; (c) limited intake of sweets and processed foods. More in detail, most of MD energy intake is provided by non-refined carbohydrate (55–60%), 30–35% from fat, and ~15% from protein (24). Carbohydrate is provided by low-glycemic index foods (i.e., wholegrain-based products and legumes) while sugar intake is <10% by limiting the consumption of sweets and sugar-sweetened beverages. Fat is mainly represented by monounsaturated fatty acids (MUFA, 19%), followed by saturated fatty acids (SFA, 9%) and polyunsaturated fatty acids (PUFA, 5%), and cholesterol is 300 mg/day (24). According to MD, plant protein should be preferred, while animal protein (fish, lean cuts of meat, eggs, and dairies) should be used as alternative options during the week (25). MD can provide relevant amounts of vitamins, minerals, and other phytochemicals (23). Over the recommendations for the frequency of food consumption, MD relies on cultural, social, and lifestyle features. In brief, a moderate intake of wine and other fermented beverages (women: one glass/day; men two glasses/day) is advised while respecting religious and social beliefs. A daily intake of 1.5–2 l of water (6–8 glasses) is recommended for proper hydration. Regular physical activity (i.e., sports, fitness, or leisure activities outdoors) should complement diet in order to sustain adequate body weight and other health benefits. Finally, seasonality of foods, biodiversity preservation, conviviality, and socialization are advocated to preserve MD cultural heritage (23).

Given the beneficial effects of MD, several efforts have been made to transfer this dietary pattern to non-Mediterranean populations for the prevention of NCDs. Nevertheless, several barriers toward adherence to MD in non-Mediterranean countries exist. Firstly, it is known that changing individual dietary habits is challenging, as it requires long-lasting modifications in behavior (26). Furthermore, there are practical, cultural, and economic factors that affect dietary changes (27). In brief, the main issues related with poor compliance to MD are affordability (high cost for transportation and commercialization), lack of knowledge (health benefits, cooking methods, recipes), and cultural differences (traditions, native crops, and environment protection vs. globalization).

On the other hand, in recent years there is a growing recognition that “healthy nutrition” should be integrated with food systems, i.e., “all the factors (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outcomes of these activities” (28). This would lead to a more sustainable diet, with relevant benefits on the health of people and the planet (29).

In line with this, the UNESCO Chair of “Health Education and Sustainable Development” of the University of Naples “Federico II” has focused part of its activities on the implementation of MD-based dietary patterns as a pivotal approach to prevent and manage NCDs. This specific task of the Chair represents a response to the call of the World Health Organization to reduce the pandemic of NCD and their risk factors (30). Indeed, the long-term objective of the UNESCO Chair of “Health Education and Sustainable Development” is to enhance the health status of populations by facilitating a “Knowledge Transfer Exchange” about the effects on human health of major cultural, nutritional, and environmental factors (30).

Against this complex background, the aim of the present review was to collect the available evidence on native crops and dietary habits worldwide, grouping the countries into 5 macro-areas (North America, Latin America, Africa, Asia, and Australia). Then, the information retrieved was used to propose feasible alternatives with similar composition of foods characterizing MD. Finally, we used all the information to develop specific “nutritional pyramids” based on the foods available in the 5 macro-areas presenting the same nutritional properties and health benefits (as well as environmental-friendly production processes) observed for MD.

## Methods

We used the UNESCO network to retrieve information about dietary habits of different countries. In brief, we interviewed native people from the 5 macro-areas to collect information about local crops, eating habits, traditional recipes,

etc. In addition, we performed complementary research by selecting national and international websites providing information about crop production and eating habits (i.e., National Department of Agriculture, USDA, Google Scholar, SciELO—Scientific Electronic Library Online, etc). Then, a 20-years literature search for this narrative review was conducted until December 2021 by searching PubMed database for articles published in the English language. Each specific food identified in the preliminary search was used as keyword “AND” (Boolean operator) combined with “health OR plasma glucose OR glucose metabolism OR plasma lipid OR lipid metabolism OR plasma insulin OR insulin resistance OR inflammation OR oxidative stress OR type 2 diabetes OR cardiovascular disease OR cancer OR risk factors OR effects OR composition OR intake OR consumption.”

Overall, our search retrieved a total of 860 studies suitable for our review. The citation pool of publications was further supplemented by analyzing the reference list of the selected articles.

Articles considered in this narrative review were (a) meta-analyses of prospective studies or randomized clinical trials; (b) observational studies and clinical trials not included in the meta-analyses that added significant information; (c) literature reviews providing the nutritional composition of the specific foods identified. Only articles published in journals in the highest impact factor quartile in the “Public Health,” “Endocrinology, Diabetes and Metabolism” or “Nutrition and Dietetics” areas were included. Moreover, we excluded notes, book chapters, letters, editorials, conference papers, articles published in languages other than English and those not specifically related to each issue of interest.

## Results

### North America

North America has been appointed as the cradle of the so-called Western diet, characterized by high intakes of refined grains, red and processed meat, pizza and fast food, potato, sweets, sugar, and high-energy beverages. It translates in increased amount of SFA (12%), refined carbohydrates (21% refined grains, fruit juice, and potatoes), and added sugars (14.4%) (31). These dietary features have been associated with poor diet quality and are a primary cause for chronic diseases and mortality in USA (32). Therefore, new approaches for promoting healthy dietary choices are advocated. Although massive changes are required to increase diet quality, the introduction of some local products could represent a first step to improve dietary habits.

Canola oil is a vegetable oil derived from a variety of rapeseed *Brassica napus* and *Brassica rapa* that originated in Canada. It contains MUFA (54% oleic acid), PUFA (21% linoleic acid and 11%  $\alpha$ -linolenic acid), and high concentrations of phytosterols (769 mg/100 mg canola oil) (33, 34).

Mounting evidence supports the hypocholesterolaemic effect of canola oil. Indeed, two meta-analyses of randomized controlled trials have shown that replacing SFA or sunflower oils with canola oil significantly reduces total and LDL-cholesterol concentrations (35, 36). Moreover, a non-linear dose-response curve suggested that replacing ~15% of total caloric intake with canola oil might provide the greatest benefits on lipid profile (36). Besides, a recent meta-analysis demonstrated that canola oil can positively affect body weight, with no major changes of other anthropometric parameters (37). The effect is greater in studies in women, patients with T2D, and when canola oil is compared to saturated fatty acids.

Pecans (*Carya illinoensis* (Wangenh.) K.Koch) are considered as the traditional tree nut in North America. They are an excellent source of MUFA, having 12 g/standard serving (28 g), and  $\gamma$ -tocopherol (24.4 mg/100 g) (38). Moreover, they present the highest total flavonoid content among nuts (34 mg/100 g), consisting mostly of flavan-3-ols and anthocyanins (39).

Human studies with pecans supplementation have addressed mainly to lipid profile. In a 4-week trial, 23 middle aged healthy volunteers were randomized to pecan supplementation (72 g/day) in addition to the habitual diet or habitual diet alone. At the end of the study, participant following pecan supplementation presented a significant reduction of total and LDL-cholesterol, and increased HDL-cholesterol concentrations, with no changes of body weight. In addition, a significant reduction of triglyceride, lipoprotein (a), and apolipoprotein B concentrations was detected (40).

Conversely, a 12-week healthy diet enriched with pecans (30 g/day) did not improve lipid profile in patients with stable coronary artery disease suggesting that the threshold of pecan doses might be higher than the recommended portion for other nuts (41).

Over the hypolipidemic effect, a 4 week incorporation of 42 g/day of pecan in a typical American diet has shown to improve glucose metabolism in middle-aged volunteers with central adiposity. In particular, the pecan-enriched diet significantly reduced fasting insulin and insulin resistance (evaluated as homeostatic model assessment, HOMA), while improving b-cell function (assessed as HOMA- $\beta$ ) (42).

Okra (*Abelmoschus Esculentus*) is a popular vegetable crop cultivated throughout the world mostly in tropical and subtropical regions. It is the main ingredient of the “Gumbo,” a popular American dish, particularly in Louisiana.

Okra is rich in fibers (8.16 g/100 g), both insoluble (4.73 g/100 g) and soluble (3.43 g/100 g), and it has been suggested that 100 g of okra could cover a 33% of the recommended daily fiber intake. It has 2% protein, 7% carbohydrates and traces of fat (43).

To the best of our knowledge, no clinical studies with okra supplementation are available so far.

However, several *in vitro* and animal studies suggested potential antidiabetic and lipid-lowering effects by virtue of the high fiber content (44, 45).

Pinto Beans (*Phaseolus vulgaris L.*) is the major dry beans in terms of production (31%) and consumption (20%) in North America (46). They provide 8–10% of the daily recommended amount of protein *per* 100 g serving and have a great fiber content (16 g/100 g) (47).

A randomized controlled crossover trial with a 3 × 3 block design tested the effect of Pinto beans incorporation into the diet for 8 weeks as compared to black-eyed peas and carrot used as control (1/2 cup/day for all tested foods). Sixteen mildly insulin resistant adults completed the trial, and an 8% reduction of LDL-cholesterol was detected after the consumption of Pinto beans (48). Interestingly, it has been reported that 1% reduction in LDL-cholesterol reduces risk for coronary heart disease (CHD) by ~1% (49). Therefore, the reduction observed after Pinto beans consumption may translate in an 8% reduction of CHD risk. Similar results were obtained in a longer-term study (12 weeks) where the same amount of Pinto beans was consumed by individual with pre-Metabolic Syndrome (MS) (increased central adiposity and one clinical feature considered in the diagnosis of MS) (50). In this study, complementary experiments in an *in vitro* colonic fermentation model showed a significant increase of propionate with Pinto beans incubation. Therefore, it can be hypothesized that the LDL-cholesterol lowering effects of Pinto beans may be linked to the microbial products (mainly propionate) derived from fiber fermentation.

As reported above, massive changes are required to improve the overall quality of the actual North American diet. The Harvard School of Public Health and other American Institution, both have proposed practical guidelines to enhance the transferability of the MD in real-life settings (32). However, to increase the feasibility of these dietary changes, the incorporation of local foods rich in fiber, phytochemical and other bioactive compounds may represent a complementary strategy. Therefore, over the main principles of the MD for animal protein-sources and sweets, the following changes are proposed:

- use canola oil as the main daily fat source (the amount should be according to individual energy needs)
- increase the intake of vegetables (at least 2 servings/day) and legumes (at least 3 serving/week), preferring local varieties (i.e., okra and pinto beans)
- use nuts for snacking, in particular pecans (42 g/day)

These changes are summarized in the new food pyramid for North America (Figure 1).

## Latin America

The traditional Latin American diet is mainly characterized by the consumption of plant-based foods, i.e., fruit, vegetables, legumes, nuts, and seeds. Starchy foods habitually consumed

are corn, potatoes, and rice. Red meat is the main protein source while small portion of animal protein are provided by poultry, eggs, fish, seafood, and dairy. Therefore, the overall daily macronutrients distribution is balanced, with 54% carbohydrate, 30% fat, and 16% protein intakes (51).

Nevertheless, many nutritional surveys have reported that Latin Americans, particularly those living in urban areas or in low-socioeconomic conditions, presented low diet quality and variety. More in details, over 25% of total energy intake was provided by high glycemic index (i.e., white rice and potato), and sugar and fat-rich ultra-processed foods (i.e., ready-to-eat foods, sugar-sweetened beverages, pastries, chips, and candies). In addition, the consumption of foods rich in fiber, micronutrients, and phytochemicals (i.e., whole grains, fruits, vegetables, beans, and nuts) represented only 17.7% of total energy intake (51, 52).

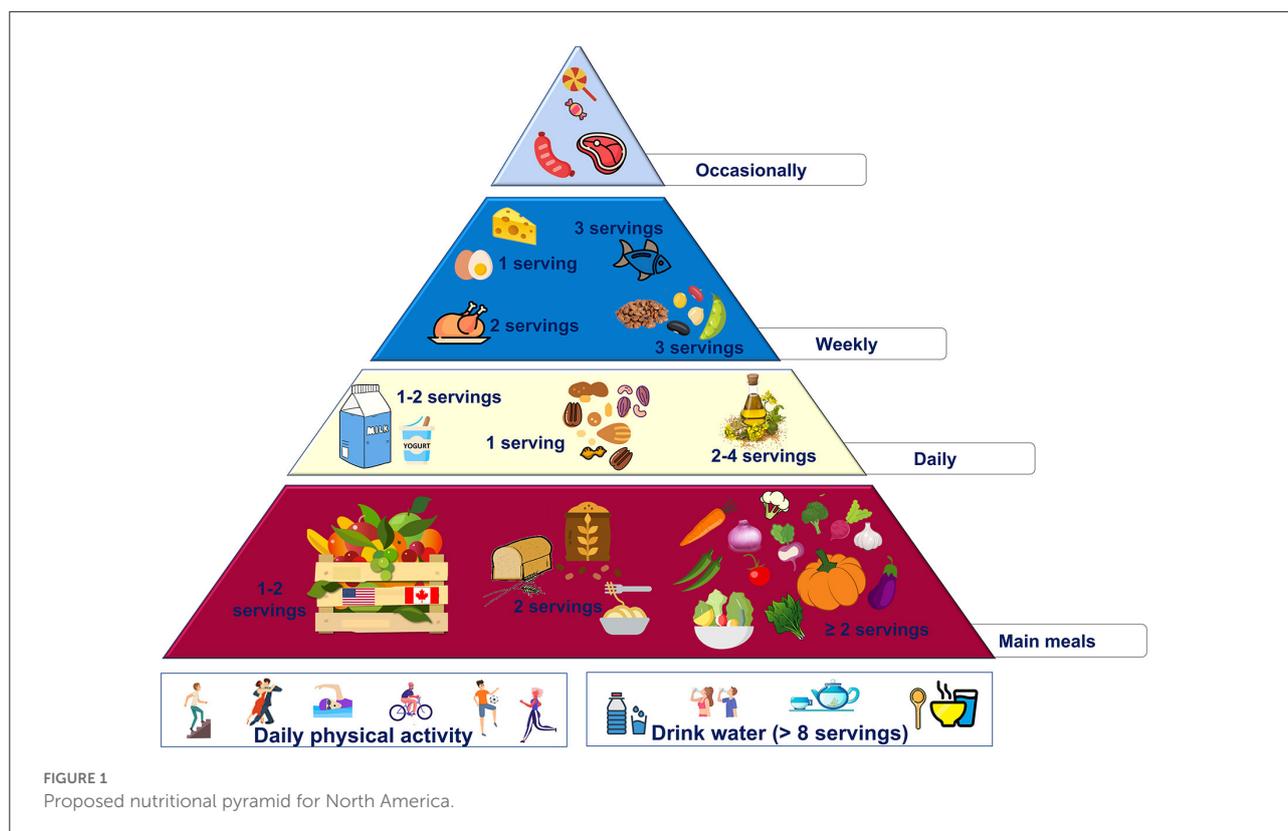
These nutritional changes have unfavorable effects on blood glucose homeostasis and lipid profile, and possibly explain the high prevalence of obesity and cardiometabolic diseases in Latin American populations (53).

Therefore, preferring the consumption of low-glycemic index starchy foods and foodstuffs with hypolipidemic and antioxidant properties is an essential shift to accomplish. In addition, promoting the consumption of diverse local foods may improve the overall diet quality in these populations.

Quinoa (*Chenopodium quinoa Willd.*) is a pseudocereal native to the Andean region. Due to its small size its botanical parts can not be separated during the milling process. Therefore, quinoa is considered as a whole grain. It has a higher total protein content (12.9–16.5%) compared to other cereals (but equal to wheat) and provides all essential amino acids (54). Fat content ranged 5–9%, which is higher than other cereals, and mainly consists in oleic acids (19.7–29.5%), linoleic (49.0–56.4%), and  $\alpha$ -linolenic (8.7–11.7%) acids. It exhibits a low glycemic index (ranging 35–53) by virtue of its small granules (particles <2  $\mu$ m in diameter), and 10% total dietary fibre, mainly soluble types (55). As compared to other cereals, 100 g of quinoa also contains higher amount of calcium (149 mg), iron (13.2 mg), and potassium (927 mg) (56).

It is also a good source of vitamins and other phytochemicals, such as polyphenols (251.5 mg/g ferulic acid, 0.8 mg/g *p*-coumaric acid, and 6.31 mg/g caffeic acid) and phytosterols (118 mg/100 g) (57, 58). Notably, it was reported that one serving of quinoa consumption (40 g raw) meets an important part of daily recommendations for essential nutrients (i.e., zinc, folic acid, magnesium, copper, and phosphorus) (59).

As for the health benefits of quinoa consumption, few human studies have been carried out so far. Recently, a meta-analysis of randomized controlled trials has reported that quinoa supplementation (20–65 g/day) may represent a useful strategy to manage cardiovascular risk factors in general adult population (60). Indeed, the addition of quinoa to the habitual diet significantly affected anthropometric parameters (body weight, waist circumference, and fat mass) as well as fasting insulin



and blood lipid concentrations in individuals with overweight obesity or pre-diabetes. The mechanisms behind these effects are still unclear (61, 62). Nevertheless, it can be speculated that fiber can be fermented by colonic microbiota with the production of short chain fatty acids (SCFAs), as occur for other wholegrains. SCFAs has been proven to modulate appetite feeling, and to improve insulin sensitivity and lipid metabolism (63).

Plátanos (*Musa sp.* also known as “green bananas”) are starchy foods used in Caribbean and Northern Latin American cooking. They contain elevated total carbohydrates amount (73.5%), but they are mainly represented by indigestible carbohydrates, i.e., resistant starch and other fibers (cellulose, hemicelluloses, and lignin) (64). Resistant starch has shown to reduce postprandial glucose response in individuals with overweight/obesity (65) as well as in patients with T2D (66). In addition, it promotes colonic fermentation and improve the gut microbiota composition, possibly influencing insulin sensitivity and other cardiovascular risk factors (67, 68).

Human studies with platano and its derived products (starch) provided promising results. A short-term trial (45-day) in 25 postmenopausal women with MS tested the effects of plátanos addition (20 g/day) to the habitual diet. At the end of the study, a significant improvement of fasting glucose concentrations and systolic blood pressure were observed, with no changes in body weight or composition. These findings have been related to the low glycemic index of platano (15.3) assessed

during the study, although the possible effects of other bioactive compounds can not be excluded (i.e., polyphenols, vitamins, and minerals) (69).

Platano starch supplementation was used in trials carried out in patients with T2D. In 4-week crossover trial 28 middle aged patients with T2D underwent a nutritional intervention either with starch (24 g/day) or soy milk (24 ml/day) dissolved in 240 mL of water. As compared to soy milk, starch supplementation induced a greater body weight loss, with no major changes in blood glucose control and lipid concentrations. Moreover, a reduction of insulin resistance (measured as HOMA-IR) was observed after starch supplementation, driven by decreased fasting insulin levels (70). In a more recent trial with longer duration (6 months), the supplementation with 4.5 g/day was tested in a group of patients with prediabetes or T2D ( $n = 61$  starch vs  $n = 52$  control). Starch significantly affected anthropometric parameters (body weight, waist, and hip circumferences, body fat) and blood pressure compared to control (71). Moreover, a significant improvement of fasting glucose and glycated hemoglobin (HbA1c) concentrations was observed after starch supplementation. These effects were obtained with no changes of the overall dietary composition, thus suggesting an independent role of starch in the improvement of metabolic control and body composition.

Avocado (*Persea americana*) is one of the main fat sources in Latin American diet and it might be preferred to olive oil due its lower cost, particularly among low-income individuals.

Avocados are rich in monounsaturated fatty acids (9.8/100 g), vitamin E (1.97 mg/100 g), and polyphenols (almost 200 mg/100 g), which can contribute to reduction of CVD risk (72). It has been reported that one avocado (136 g) has nutrient and phytochemical profiles similar to 40 g of nuts (72) and presents the same MUFA amount contained in almost 18 ml of olive oil (73).

The main health benefits of avocado consumption are related to the improvement of blood lipid concentrations. Indeed, several meta-analyses (74–76) have reported a moderate to large effect on LDL cholesterol (−3.54 mg/dl; 95% CI: −9.66, 2.58 mg/dl) even great heterogeneity was observed among studies. Moreover, avocado consumption (1 to 3 avocado/day) has shown to significantly increase HDL-cholesterol concentrations (3.90 mg/dl; 95% CI: 0.44, 7.36 mg/dl) (75). In addition, the consumption of one avocado/day (almost 136 g) has shown to improve oxidative stress (77) and cognitive function (78) in individuals with overweight/obesity by virtue of its bioactive compounds with antioxidant properties, in particular polyphenols (almost 200 mg), lutein and zeaxanthin (370 µg) (72).

Açaí berries (*Euterpe oleracea Mart.*) are the fruit of a typical palm tree found in the floodplains along the Amazon River estuary. They can be green (white açaí) or purple (dark açaí) according to the variety with no difference in nutritional composition. They are good sources of fat (32–48 g/100 g, mainly omega 6 and 9), fiber (44 g/100 g) polyphenols (424.9 mg/100 g), particularly anthocyanins (cyanidin 3-glucoside, cyanidin 3-rutinoside, and peonidin-3-rutinoside), proanthocyanidins, phenolic acids (gallic, protocatechuic, p-coumaric, ellagic, vanillic, and syringic acids), stilben (resveratrol), and other flavonoids (epicatechin, quercetin, catechin, velutin, homoorientin, orientin, isovitexin, and taxifolin deoxyhexosein) (79).

Few human trials evaluating the effects of Açaí berries on health are available. In a short-term trial (4 weeks), 10 overweight volunteers were asked to consume 200 g/day of açaí pulp. At the end of the study, an improvement of fasting glucose, total and LDL-cholesterol concentrations was observed (80). The same amount of açaí pulp was used in a study focusing on the potential antioxidant activity of açaí berries in 35 young women (81). After 4-week, açaí pulp increased the activity of antioxidant enzymes, total antioxidant capacity, and reduced the production of reactive oxygen species and protein carbonyl concentrations. In a more recent randomized, double-blind, placebo-controlled clinical trial, 69 overweight dyslipidemic patients were assigned to a hypocaloric diet + 200 g/day of açaí pulp or hypocaloric diet alone. The hypocaloric diet was designed to achieve a 6 kg-weight loss with a balance macronutrient distribution (protein 15%, 45–60% carbohydrate,

and 25–30% fat). After 8 weeks, in the group consuming açaí pulp, a significant improvement of oxidative stress (measured as plasma 8-isoprostane concentrations) and inflammation (evaluated as IL-6 and IFN-γ) was observed (82).

As reported above, the traditional Latin American diet is a plant-based dietary pattern and provides adequate amount of the main macro- and micronutrients. However, globalization has induced a shift toward Western dietary habits. In addition, some traditional foodstuffs should be limited and substituted with other having more beneficial characteristics. Therefore, over the main principles of the MD for animal protein-sources and sweets, the following changes are proposed:

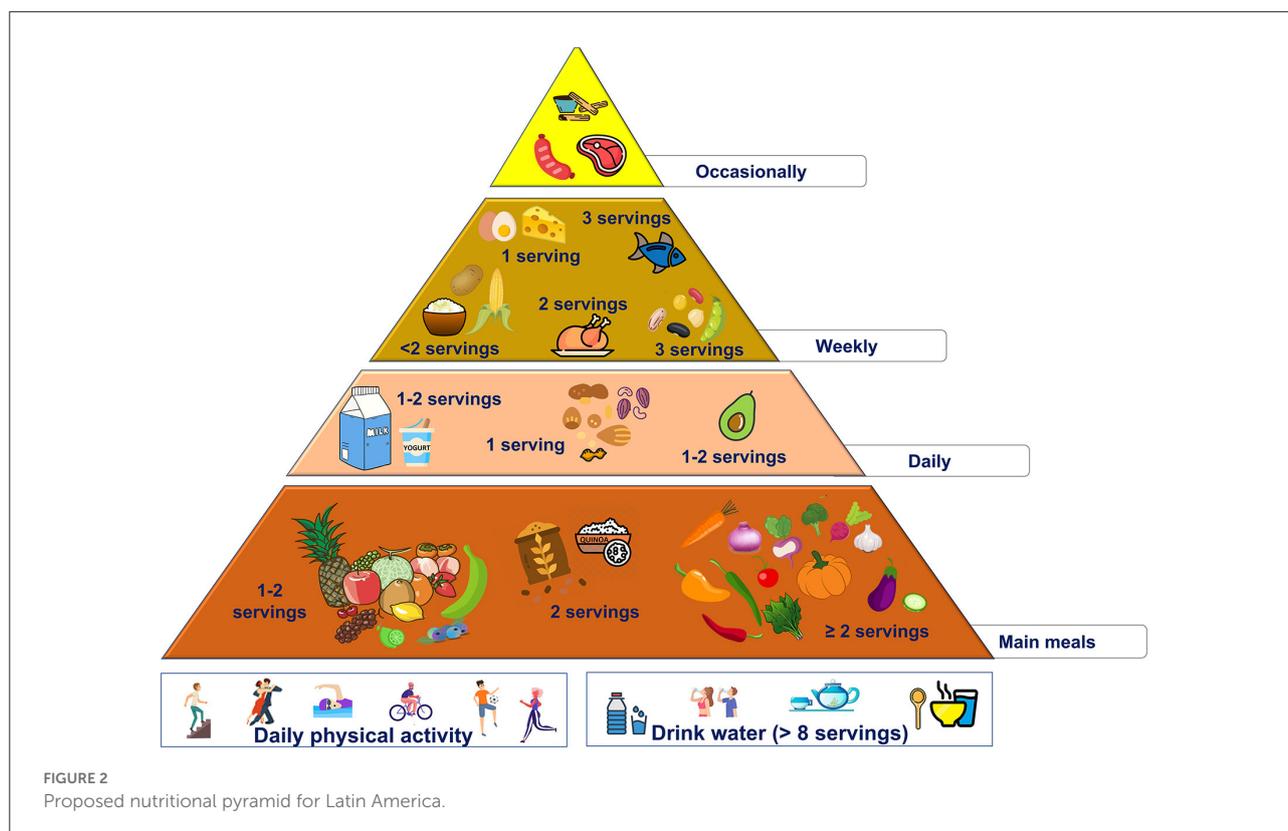
- 2 servings/day of starchy foods with low glycemic index (quinoa, plátanos, and wholegrain)
- no more than 2 servings/week of starchy foods with high glycemic index (rice, corn, and potato)
- use avocado as the main daily fat source (the amount should be according to individual energy needs)
- increase the intake of vegetables (at least 2 servings/day) and fruits (1 or 2 servings/day), preferring fruit with high antioxidant activities (like açaí and other berries).
- These changes are summarized in the new food pyramid for Latin America (Figure 2).

## Africa

Although malnutrition and food shortages are still prevalent in this continent, many African countries underwent the “nutrition transition” during the last years. Indeed, very recently the profound changes that have taken place in Africa have been reported (83). Overall, these dietary changes consist of a shift from the consumption of natural foods with marginal handling—mainly fruit, vegetables, and legumes—to highly processed foods (refined carbohydrates, SFA and trans fats, added sugars, salt, and food additives). Notably, this phenomenon occurred also in African Mediterranean countries (Egypt, Libya, Tunisia, Algeria, and Morocco) (84). Unfortunately, to the best of our knowledge, no clear information on the actual nutritional habits of African populations is available so far. This lack of information is mainly due to methodological limitations in the assessment of dietary intake as reported in previous studies (85).

Nevertheless, as for other continents, it could be hypothesized that promoting the consumption of local foods could improve the diet quality in African populations.

Teff (*Eragrostis tef*) is a grain native to Ethiopia and Eritrea (Eastern Africa). Teff is the smallest of all grains and is considered a minor cereal due to its meager use, limited to a few regions of the world (86). Teff is a good source of dietary fiber (8 g/100 g), and it has higher amount of protein (11–13%) as compared to other grains (87). As for micronutrients, teff



contains the highest iron and calcium contents (11–33 mg and 100–150 mg, respectively) among all grains (86). Therefore, a cross-sectional study in 592 pregnant women suggested that the lower risk of anemia in Ethiopia might be explained by the daily consumption of this grain (88).

Moringa (*Moringa Adans*) is a plant that can grow in extreme climatic conditions (hot dry and less fertile soils) and is widespread in Ethiopia and Kenya. All botanical parts of Moringa (flowers, pods, leaves, and seeds) have been traditionally used for their potential beneficial effects. Indeed, Moringa is a good source of phytochemicals and micronutrients (89). As for vitamins, Moringa has shown a content of vitamin A and  $\beta$ -carotene (11,300–23,000 IU and 6.6–6.8 mg per 100 g), as well as vitamin C (200 mg/100 g), which are even higher than other plant foods (i.e., carrots and pumpkins, and oranges and kiwi, respectively). In addition, the amount of Vitamin E is similar to nuts (9.0 mg/100 g) whereas Moringa contains more polyphenols than fruit and vegetables (88). Pods and seeds contain unsaturated and essential fatty acids, especially oleic acid as well as omega 3, that make Moringa a source of healthy fat (90).

This nutritional profile might contribute to the antioxidant, antimicrobial, and anti-inflammatory activities associated with its consumption. Nevertheless, most of the evidence is provided by *in vitro* experiments and studies in animal models (91). Besides, a recent meta-analysis of 46 studies in animal models

suggested a potential role of Moringa-derived products in the reduction of glucose and lipid levels (92).

Native fruit and vegetable, particularly from South Africa, have been reported as relevant contributors to the survival of local communities. It is worth mentioning that almost 119 species of plant-derived products grow in Africa (93). Undoubtedly, fruit and vegetable provide huge amounts of vitamins, minerals, and other phytochemicals with beneficial effects on health.

Recently, Nkosi et al. (94) evaluated the nutritional composition of ten African fruit [*Ficus capensis* Thunb (Cape fig), *Landolphia kirkii* (Sand apricot vine), *Engelerothymum magalismsontanum* (Transvaal milkplum), *Parinari curatellifolia* (Mobola plum), *Sclerocarya birrea* (Marula), *Strychnos spinosa* (Green monkey orange), *Strychnos madagascariensis* (Black monkey orange), *Syzygium cordatum* (Water berry), *Ximenia caffra* (Sour plum), and *Vangueria infausta* (Wild medlar)]. They detected different profile of phenolic compounds thus suggesting a potential involvement in different biological activities. Indeed, *in vitro* experiments showed that Mobola plum, Water berry, and Marula presented the strongest antioxidant activity. Conversely, Sour plum and Sand apricot vine induced the highest inhibition of carbohydrate hydrolysing enzymes, thus suggesting a potential role in carbohydrates digestion.

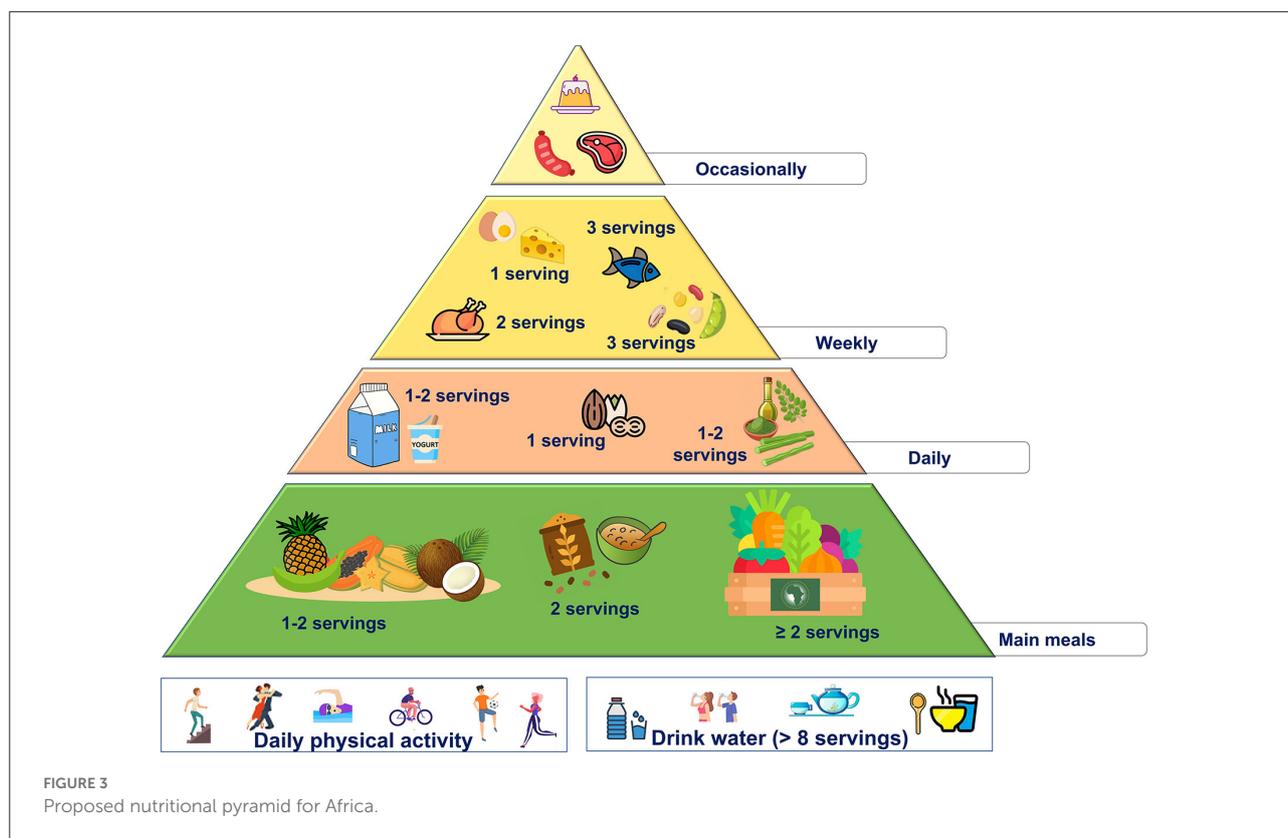


FIGURE 3  
Proposed nutritional pyramid for Africa.

Unfortunately, scientific evidence in humans or large information on food composition are lacking (93). Nevertheless, the consumption of local fruit and vegetable should be encouraged to improve the diet quality and sustainability of food systems.

In conclusion, to improve diet quality in African populations the proposed changes are:

- favor the consumption of native grains like teff by consuming at least 2 servings/day of teff-derived products
- use Moringa oil as daily fat source (the amount should be according to individual energy needs)
- increase the intake of plant-based foods according to African traditional diet and endorse the use of native fruits (1 or 2 servings/day) and vegetables (at least 2 servings/day).

These changes are summarized in the new food pyramid for Africa (Figure 3).

## Asia

The Asian continent is very extended and, consequently, dietary habits might be more heterogeneous across the different

countries than in other continents. Although each Asian region has its distinct traditions, there are many unifying characteristics that allows us to perform a critical appraisal of the nutritional profile of population living in Asia.

Grains account for the main part of crops in Asian countries this continent (95–97). Indeed, carbohydrates intake is high (65% to >80% of daily energy intake), with rice and its derivatives being the main dietary sources (98). Although different rice varieties are consumed across Asian countries, white rice is the main contributor to carbohydrate intake. In addition, the higher consumption of rice, the lower intake of fat sources and wholegrain (almost 15 and 5%, respectively) (99). This translates in a high-carbohydrate-low-fat diet characterized by the consumption of food with high glycemic index and glycemic load (99). Several studies have shown that both carbohydrate amount and quality associated with MS and metabolic diseases in Asian countries (100, 101) as well as in other populations (102–104).

Besides, the prevalence of micronutrient deficiencies (mainly vitamin A, vitamin B12, iron, iodine, and folic acid) is widespread in different Asian countries (105).

Therefore, the main dietary changes that should be encouraged are related to the consumption of low-glycemic index starchy foods, adequate carbohydrate intake (<60%), and foodstuffs containing vitamins, minerals, and phytochemicals.

Barley (*Hordeum vulgare* L.) is a major food crop in Middle East (Iran, Iraq, and Syria) and Turkey, but also in Central and South Asia (mainly Kazakhstan, Afghanistan, India, and Pakistan) (46). It is classified as wholegrain, and it received the health claim from its lowering effects on glucose and cholesterol levels by the Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA) (106, 107). These metabolic effects are triggered by  $\beta$ -glucan, a viscous soluble dietary fiber, which can form a viscous gel that can reduce carbohydrate and fat absorption in the gut (108). On the other hand, it is more prone to fermentation by gut microbiota than other type of fibers, thus inducing a greater production of beneficial microbial metabolites (i.e., SCFAs) (109).

Sesame seeds (*Sesamum indicum*) are traditional food in East Asia, but its oil is widely used in the whole continent (110). Sesame is richer in lignans (sesamin, sesamol, sesamol, episesamin) and  $\gamma$ -tocopherol than other foods (i.e., flaxseeds, nuts, grains, and legumes) (111). In addition, sesame oil contains a beneficial fatty acids profile, consisting of linoleic acid (41%), oleic acid (39%), palmitic acid (8%), stearic acid (5%) (112).

Studies in humans have investigated the possible effects of daily sesame oil consumption on cardiovascular risk factors (113, 114). A meta-analysis of 8 randomized controlled trials ( $n = 843$  participants) showed that sesame consumption (35 g of sesame oil) can reduce systolic as well as diastolic blood pressure ( $-7.83$  and  $-5.83$  mmHg, respectively) (113). More recently, Yargholi et al. evaluated the effect of sesame consumption on blood glucose control in a meta-analysis of 8 randomized controlled trials ( $n = 382$  participants with T2D). A significant reduction of fasting blood glucose ( $-28$  mg/dl) and HbA1c ( $-1.00\%$ ) levels were observed with the consumption of 30 g of sesame-derived products (114).

Marine macroalgae i.e., seaweeds, have been consumed for centuries in Far East Asia, mainly Japan and Korea (115, 116). They are a great source of complex polysaccharides, minerals, proteins, and vitamins, and well as of several phytochemicals (117, 118). In addition, seaweeds have a significant amount of essential PUFA, namely eicosapentaenoic acid (EPA; 20:5 n-3) and docosahexaenoic acid (DHA; 22:6 n-3), and their precursors  $\alpha$ -linolenic acid (ALA; 18:3 n-3) and docosapentaenoic acid (DPA; 22:5 n-3) (119).

The regular consumption of seaweeds (15 g/day) has been associated with a reduced risk of CVD risk (119, 120). This effect is triggered mainly by the lowering-triglyceride effect of DHA and EPA, as stated also by a health claim by EFSA (121).

Nevertheless, some seaweeds have shown to influence other CVD risk factors. Spirulina (*Spirulina platensis*), is a blue-green algae which grows naturally in high salt alkaline water reservoirs in subtropical and tropical areas of Asia. It is a good source of high-quality protein (60–70%/dry weight) and contains an iron with high bioavailability as compared to other foods (i.e., grains) (122). Interestingly, in a meta-analysis of randomized controlled

trials the spirulina supplementation decrease total and LDL-cholesterol ( $-47$  and  $-41$  mg/dl, respectively) while increase HDL-cholesterol concentrations (6 mg/dl) (123). Besides, a recent meta-analysis has shown that spirulina consumption (1–8 g) decrease systolic and diastolic blood pressure ( $-4.59$  and  $-7.02$  mmHg, respectively), with greater reduction in patients with hypertension (124).

Wakame (*Undaria pinnatifida*) is one of the most consumed macroalgae worldwide. It contains higher amounts of alginate, a polysaccharide with high viscosity (125). Therefore, its potential role in the modulation of glucose and lipid metabolism has been postulated.

Izaola et al. (126) investigated the effects of a wakame-enriched snack on CVD risk factors in 40 individuals with MS. After 8 weeks, a significant reduction of total and LDL-cholesterol ( $-10$  and  $-8.9$  mg/dl, respectively) observed with no effects on glucose metabolism. More recently, in an acute cross-over trial, wakame intake (5 g) significantly reduced glucose and insulin response to a mixed meal compared to the control (127). However, it is worth mentioning that seaweeds contain iodine their overconsumption may pose a risk of thyroid diseases in susceptible individuals (128). In addition, due to pollution contamination in the aquatic system, seaweeds might contain heavy metals and metalloids (129). Therefore, regular consumption of seaweeds should be monitored due to the potential health risk in the long term.

Soy (*Glycine max*) and its derivatives are largely used in Asian countries. Soy is an East Asian native leguminous plant rich in proteins (36–46%, depending on the variety), lipids (18%), soluble carbohydrates (15%), and fiber (15%). In addition, soy also contains several bioactive compounds such as lecithin (0.5%), sterols (0.3%), isoflavones (0.1%), tocopherols and tocotrienols (0.02%) (130).

Epidemiological studies have shown an inverse association between soy-based foods and the incidence of CVD, T2D, and certain types of cancer (breast and stomach) (131–137). These effects are related to its isoflavone content. Indeed, isoflavones are phytoestrogens which can bind the estrogen receptor thus having an estrogen-like activity (130). Moreover, soy proteins ( $\beta$ -conglycinin and glycinin) and peptides obtained by their intestinal hydrolysis have repeatedly shown a cholesterol-lowering effects by promoting LDL-receptor expression (138). Notably, soy intake (25 g/day) has been granted by FDA for its beneficial effects on cardiovascular health (139).

As reported above, the traditional Asian diet is particularly rich in starchy foods with high glycemic index, and lower amount of other nutrients and possibly micronutrients. Therefore, some traditional foodstuffs should be limited favoring other foodstuff with more beneficial effects on health. Accordingly, the following changes are proposed to improve diet quality:

- 2 servings/day of starchy foods with low glycemic index (barley and wholegrain)
- no more than 2 servings/week of starchy foods with high glycemic index (rice, and noodles)
- use sesame oil as the main daily fat source (the amount should be according to individual energy needs), and use sesame seeds to enrich soups
- increase the intake of vegetables (at least 2 servings/day) and fruits (1–2 servings/day), preferring fruit with high antioxidant activities.
- 2 servings/week of plant protein sources (soy-derived foods)
- 1 serving/day of seaweeds (in particular, spirulina and wakame)

These changes are summarized in the new food pyramid for Asia (Figure 4).

## Australia

The actual Australian diet resembles a Western dietary pattern, with plant-based foods replaced by high-fat, energy-dense, and greater animal-derived foodstuffs (140). Therefore, due to the “nutrition transition,” dietary changes favoring healthier food choices of local products could represent a first step to improve diet quality also in Australia.

Macadamia nut (*Macadamia integrifolia*), a tree nut native to Australia, contains ~75% fat, higher levels of MUFA than any other food sources (more than 60 g/100 g), and phenolic compounds (141).

As for the potential health benefits of macadamia nuts intake, few studies in humans are available. In the study by Garg et al. 17 hypercholesterolemic male were given macadamia nuts (40–90 g/day, accounting for 15% of total energy intake) for 4 weeks. At the end of the intervention, plasma markers of inflammation (leukotriene) and oxidative stress (8-isoprostane) were significantly lower in the group consuming macadamia nuts than control (leukotriene:  $-323 \pm 96$  pg/ml and 8-isoprostane:  $197 \pm 19$  pg/ml) (142). In addition, in a 5-week clinical trial with macadamia nut supplementation (40–90 g/day, accounting for 15% of total energy intake) significantly reduced total and LDL-cholesterol as compared to control ( $-20 \pm 7$  and  $-12 \pm 5$  mg/dl, respectively) in a group of 25 hypercholesterolemic men and women (143).

Atlantic salmon (*Salmo salar*) and Barramundi (*Lates calcarifer*) are two major Australian farmed fish species. They are rich in omega-3 PUFA with 980 and 790 mg/100 g, respectively (144). As reported above, omega 3 fatty acids (namely DHA and EPA) bear a health claim for their triglyceride-lowering effects (121), possibly contributing to the reduction of CVD risk.

Native fruits, i.e., Davidson’s plum (*Davidsonia spp.*), pepper berry (*Tasmannia lanceolata*), finger lime (*Citrus australasica*

*var. sanguinea*), are great contributors for dietary intake of vitamins, minerals, and other phytochemicals with beneficial effects on health (145).

Preliminary studies suggested that the extracts of these fruits might inhibit cancer cells growth in several *in vitro* models (pancreas, breast, lung, brain, skin, colon, and ovary cancers) (146, 147). Unfortunately, to the best of our knowledge, no clinical studies in humans are available so far.

As reported above, important changes are required to improve the overall quality of the actual Australian diet. However, to increase the feasibility of these dietary changes, the incorporation of local foods rich in fiber, phytochemical and other bioactive compounds may represent a complementary strategy. Therefore, over the main principles of the MD for animal protein-sources and sweets, the following changes are proposed:

- use macadamia oil as the main daily fat source (the amount should be according to individual energy needs)
- increase the intake of vegetables (at least 2 servings/day), preferring local varieties
- increase the intake of fruits (>2 servings/day), preferring local varieties (i.e., Davidson’s plum, native pepper berry, and finger lime)
- increase the intake of fish rich in omega-3 PUFA (2–3 servings/week), preferring local varieties (i.e., Atlantic salmon, barramundi)
- use macadamia nuts for snacking, in particular (40–90 g/day, accounting for 15% of total energy intake).

These changes are summarized in the new food pyramid for Australia (Figure 5).

## Conclusion and future perspectives

Although the pivotal role of the MD in the prevention and management of NCDs, it is not easy to transfer this dietary pattern to other populations. Indeed, the adoption of the real MD implies to shift from local traditions that have been in those territories for centuries to new and unknown habits. Therefore, it seems more reliable—and also desirable— that each country rediscovers its own heritage to develop a healthier nutrition pattern based on traditional and local foods. This would be aligned with UNESCO advocacy to preserve cultural identity, continuity of communities, and environment.

Some non-Mediterranean dietary patterns, as Nordic (148) and Okinawan (149) diets, have been shown to reduce disease risk and mortality. These beneficial effects are linked to a nutritional profile that is superimposable to MD (150, 151). Therefore, it would be possible to obtain healthful effects by combining different foodstuff belonging to the own country

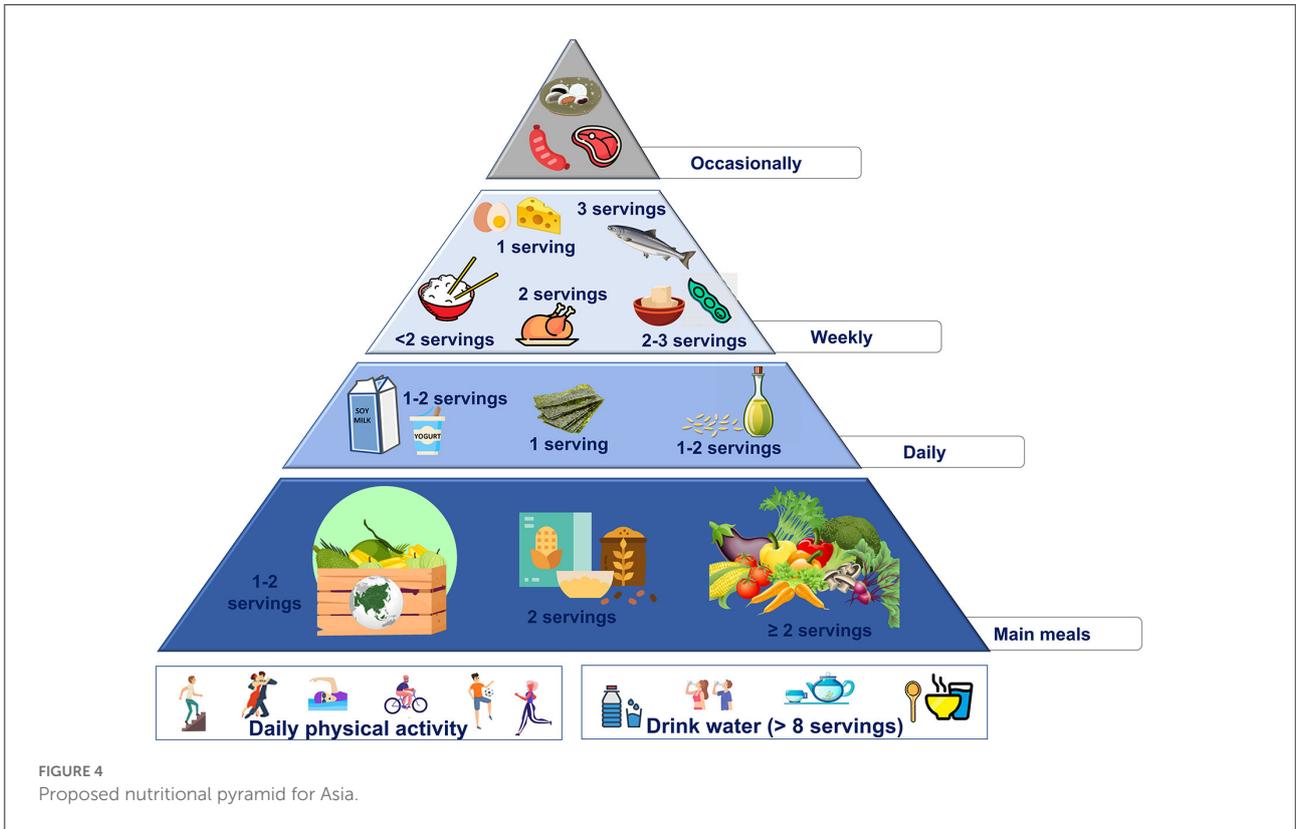


FIGURE 4  
Proposed nutritional pyramid for Asia.

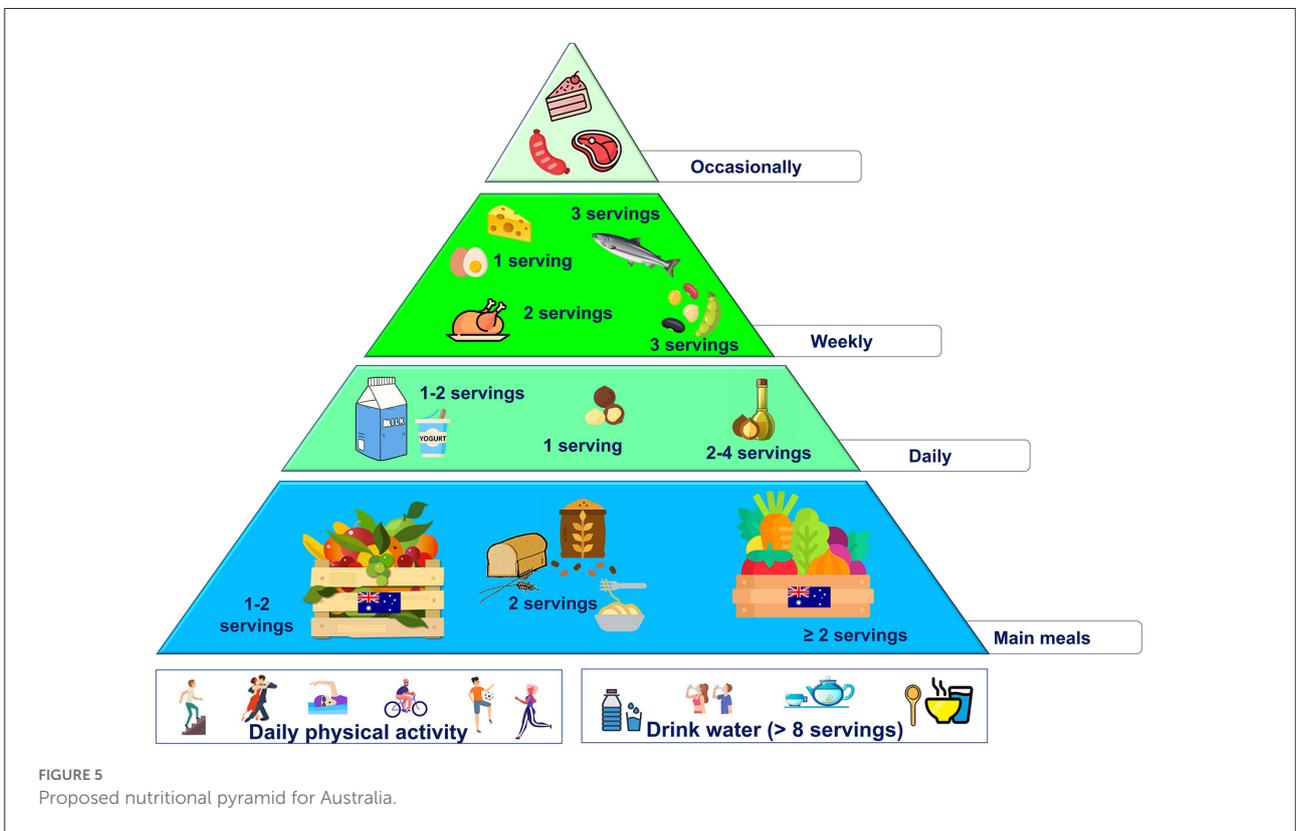


FIGURE 5  
Proposed nutritional pyramid for Australia.

with significant advantages not only for people but also for the environment.

The present review is an attempt to promote a healthy and sustainable dietary model based on the nutritional properties of MD but implemented at the local level by using the food products available in different areas of the world. Nevertheless, as the first release of the research project “Planeterranea,” this manuscript provides an overview of the rationale, aims, and main results, and the limitations will be addressed in future publications. Indeed, some of the analyzed macro-areas (Asia, Africa) include many heterogeneous countries with specific eating habits. Therefore, it is necessary to evaluate whether a macro-area might require multiple nutritional pyramids to endorse the compliance of the different populations.

On the other hand, the sustainability of the proposed pyramids should be evaluated in *ad hoc* investigations that should consider (a) affordability in terms of commercialization, costs, farming, etc.; (b) impact on local economies that should meet the needs of growing populations; (c) greenhouse gas emissions of local crops as compared to long-traveling food products.

Finally, more studies are needed to evaluate the bioavailability of micronutrients and bioactive compounds contained in the identified foods. In addition, the safety of local foods with potential health benefits might be investigated to assess whether they might have detrimental side effects in the long term.

In conclusion, it is important to increase global knowledge about healthy and sustainable dietary patterns rather than force people to a useless change. Therefore, nutritional research should focus not only on the amount and frequency of food consumed but also on cultural behaviors, socio-economic conditions, food quality and processing. This would lead to a

sharply increased adherence to nutritional recommendations with a relevant impact on public health and clinical practice.

## Author contributions

CV, PP, and AC: conceptualization and validation. CV and PP: writing—original draft preparation. GM, LB, DL, CG, and FM: review and editing. AC: supervision. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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