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Water Global Health Benefit: The Water Footprint of the Dietary Patterns and the Acceptability of a 100% Plant-Based Diet †

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Abstract: Water is exhaustible but fundamental from the perspective of global health. Food choices seem to play a relevant impact on human water consumption. We assessed the water footprint of widespread dietary patterns, and we used a mix-methods approach. We administered an adapted version of a 17-item questionnaire to a sample of young subjects, aiming to assess the level of acceptability of the diet that showed the lowest water consumption. The 100% plant-based diet was the winner, but its acceptability was weak. Our findings support the current evidence promoting adherence to a low or non-animal-based diet, which favors human and environmental health.

Keywords: food literacy; environmental health literacy; Mediterranean diet; hand washing

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1. Introduction

Water is one of the most precious natural resources, because it is essential for life, so it is fundamental to warrant its use for everyone in terms of human rights and living with dignity [1–3]. Moreover, water on Earth is not endless but limited and exhaustible, and the current data show a worrying growing water scarcity. Already, today, in some areas of the planet, about eight hundred thousand people lack access to sufficient and safe water, and about three billion people are not benefitting from adequate sanitation [4]. Some experts have also observed that there is a significant decline in the availability of fresh water, and it results in harmful effects on human health [5].

During the pandemic period, water availability, as well as water consumption, were put in crisis due to the fact that one of the most effective interventions in curbing the spread of COVID-19 has been ongoing sanitation and cleaning hands [6,7]. For this reason, now more than ever, water scarcity is a critical condition at the forefront.

The current water demand is very high and will grow steadily in the future. It has been estimated that 70% of fresh water is absorbed by agriculture, while 22% is for the industry, and the remaining 8% is for domestic purposes [2].

In addition, Willett et al. [8] stated that global food production is among the largest drivers of global environmental change and strongly contributes to freshwater use. The same experts [8] have defined the characteristics of the so-called planetary diet, which is a plant-based diet and adequate in preserving human and environmental health. This kind of diet is different from a vegan diet. The vegan diet is a dietary pattern that allows consuming only vegetal food products, and for this reason, it is also called a 100% plant-based diet. On the other hand, a planetary diet can be graphically represented by a pyramid in which the basis is represented by vegetables and fruits and bread and cereals and that includes an abundant consumption of legumes, nuts, and vegetal oil instead of animal protein and fat. The low consumption of animal products is shared with a planetary diet. On the contrary,

the Western diet [9] is poor in terms of vegetables and fruit consumption and rich in animal protein and fat.

From this perspective, the Mediterranean diet [10] and the flexitarian diet [8] have similar characteristics as the planetary diet. Finally, diets for athletes [11] involve a slightly higher consumption of energy, carbohydrates, and proteins with respect to the Mediterranean diet, with a great attention to hydration and dietary shortenings near or during the athletic performance.

Starting from the rationale that a strong relationship among environmental and human health exists [8], we conducted the present research aiming to calculate the water consumption:

(1) of five widespread dietary patterns (Western diet [9], Mediterranean diet [10], flexitarian diet [8], diet for athletes [11], and 100% plant-based diet [12]).
(2) In addition, we assessed the level of acceptability of the "winner" diet, i.e., that proved to be the one with the lowest water consumption, by involving a convenience sample of young adults who voluntarily filled in an online questionnaire.

2. Material and Methods

We based our study on specific definitions of the concepts of water footprint and acceptability that are described as follows. The water footprint of a food product was intended as the total volume of fresh water that is used directly or indirectly to produce it, and it is estimated by considering the water consumption and pollution in all the steps of the production chain [13]. Regarding the term acceptability, it has been conceptualized as the level of preference of a dietary pattern referred by people and could represent an indicator of an individual's propensity towards adopting specific dietary habits [14]. Two phases were considered in our research: the first one foresaw the calculation of the water footprint of the five dietary patterns described (Phase 1); the second assessed the level of acceptability of the winner diet (Phase 2).

2.1. Water Footprint of the Five Selected Dietary Patterns, Phase 1

Firstly, we planned a daily hypothetical food plan for each dietary pattern (Western diet, Mediterranean diet, flexitarian diet, diet for athletes, and 100% plant-based diet), which are shown in the Appendix A (please see Table A1). Calculations of the nutrients were based on the food databank of the Italian National Food Research Institute (ex-INRAN, nowadays renamed CREA) [15], and we also referred to the latest recommended nutrient intake levels for the Italian population (LARN) and those classified by the Italian Society of Human Nutrition (SINU) [16].

Secondly, we calculated the water footprint of the five dietary plans, considering both a water footprint calculator (m^3 per year) [17] and manual calculations (liters per capita per day) on the basis of tables with a complete list of the water consumption of foods and beverages retrieved by the literature [4]. In both methodological approaches, the water consumption was estimated by adding the values of the water footprint of each food item in the dietary plan.

2.2. Level of Acceptability, Phase 2

A survey was conducted to evaluate the level of acceptability of the winner diet, and N = 126 young adults (mean age, 26 years old; females, 62.7%) participated in the study. Data were collected using a self-administered questionnaire that included a general section for sociodemographic characteristics and the 17-item questionnaire, named Food Acceptability Questionnaire (FAQ) [14], previously translated and adapted to the Italian language. Participants voluntarily agreed to join the study and filled in the questionnaire administered online. All the adopted procedures were in accordance with the ethical standards of the Declaration of Helsinki, and the data were collected anonymously.

3. Results and Discussion

Different dietary patterns need different amounts of natural resources to be fulfilled, with dissimilar environmental impacts and effects on human health. Moreover, they call on different behaviors on the part of the consumers, which can be represented in the composition of a food pyramid. This paper focuses on some of the most widespread dietary patterns (Western diet, Mediterranean diet, flexitarian diet, diet for athletes, and 100% plant-based diet) and tries to compare them in terms of water consumption. We also assessed the consumers' level of acceptability of the most water-saving diet we identified.

In the literature, high adherence to the Mediterranean diet has been associated with a reduced incidence of chronic diseases such as cancer, cardiovascular, and neurodegenerative diseases, as well as overall mortality [18]. Similar evidence has been collected for dietary patterns based on vegetal products (i.e., vegan and flexitarian diets), which seem to also produce health benefits for the body weight, improving the markers of metabolic health and blood pressure, and reduce the risk of type 2 diabetes [19]. In contrast, the Western dietary pattern seems to be strongly associated with a high risk of general and central obesity, metabolic syndrome, type 2 diabetes, and cardiovascular diseases [9].

Regarding athletes' diets, an appropriate dietary scheme tailored to the individual's characteristics could favor optimal sports performances, as well as health status [11].

Similarly, evidence suggests that dietary patterns based on fruits and vegetables combine positive human health effects with smaller environmental impacts in terms of cropland use, fresh water consumption, greenhouse gas emission, nitrogen and phosphorus application [8].

Regarding the water footprint of the five identified dietary patterns, the results are summarized in Tables 1 and 2.

Table 1. Software calculations of the water footprint.

	Dietary Patterns	Water Footprint (m^3 per Year)
I.	100% plant-based diet	354
II.	flexitarian diet	486
III.	Mediterranean diet	640
IV.	Western diet	1.094
V.	diet for athletes	1.126

Table 2. Manual calculations of water footprint.

	Dietary Patterns	Water Footprint (Liters per Capita per Day)
I.	100% plant-based diet	2.089
II.	flexitarian diet	2.335
III.	Mediterranean diet	2.400
IV.	diet for athletes	3.241
V.	Western diet	3.780

The 100% plant-based diet was the "winner", since it had the lowest water footprint in both calculations. Additionally, the data collected by means of the 17-item questionnaire showed an intermediate level of acceptability (mean score, 3.86).

We noted that the diet for athletes had the highest water footprint, according to the first, but not the second, form of calculations, whereas the Western diet was the most water-consuming [4] (please see Tables 1 and 2).

Considering our results, we argue that it is possible to identify two different dietary clusters regarding water consumption: a low-water consumption group that includes the 100% plant-based diet, the Mediterranean diet, and the flexitarian diet (mean water footprint, 493 m^3 per year or water consumption, 2.275 L per capita per day) and a second high-water consumption group that includes the Western diet and diet for athletes (mean water footprint, 1.110 m^3 per year or water consumption, 3.510 L per capita per day).

4. Conclusions

To reach a high level of adherence to a healthy diet whilst achieving a low environmental impact is one of the Sustainable Development Goals (SDGs) of the UN 2030 Agenda, whose explicit aim is to improve people's quality of life while protecting our planet's resources [20].

According to our results, adherence to a 100% plant-based diet could favor the reduction of water consumption (in terms of 740 m^3 per year of water or 1.691 L per capita per day). We argued that the adoption of a dietary pattern with a high amount of foods obtained from plants could contribute to limiting the environmental impact and , at the same time, better protecting human health. Preserving water is, in fact, essential from an ethical, as well as a sustainable, point of view to balance food production with food safety and to protect a precious and finite resource that is crucial for life.

However, a strong limitation in promoting this dietary model is represented by the intermediate level of people's acceptability: this is a critical aspect that should be considered in any attempt to promote dietary patterns close to vegan.

Future interventions should therefore be focused on increasing people's awareness and responsibility for water's impact of our food choices and how to reduce, by means of the most appropriates ones, water consumption.

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Informed Consent Statement: Participants voluntarily agreed to join the study and filled in the questionnaire administered online. The patient's consent was collected orally and this study did not require ethical approval.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Daily hypothetical food plan for the five dietary patterns considered.

Hypothetical Plan * for Western Diet	Hypothetical Plan * for Mediterranean Diet	Hypothetical Plan * for Flexitarian Diet	Hypothetical Plan * for Diet for Athletes	Hypothetical Plan * for 100% Plant-Based Diet
Breakfast - whole milk, 150 mL - sugar breakfast cereal, 40 g - biscuits, 3–4 (optional choice: a slice of bread with scrambled eggs, 2)	**Breakfast** - coffee espresso, 30 mL - low fat milk, 150 mL - a slice of whole grain bread + marmalade, 25 g - fresh fruit, 1 (optional choices: a slice of homemade fruit tart *or* whole-grain cereals for breakfast, 40 g)	**Breakfast** - low fat milk *or* vegetable milk (such as almond or soy milk), 150 mL - whole-grain cereals for breakfast, 40 g - fresh fruit, 1 (optional choices: a slice of homemade fruit tart *or* biscuits, 3–4)	**Breakfast** - low fat milk, 200 mL - a slice of whole grain bread + marmalade, 25 g - fresh fruit, 1 (optional choice: oatmeal, 50 g + one banana)	**Breakfast** - vegetable milk added with calcium and vitamin D (such as almond or soy milk), 150 mL - chia seeds, 10 g - vegan biscuits, 3–4 *or* oat flakes, 40 g - fresh fruit, 1
Mid-morning Snack a slice of white bread + butter, 25 g + fruit jam, 25 g	**Mid-morning Snack** - low fat yogurt (without added sugar), 125 mL - linoleum seeds, 1 teaspoon	**Mid-morning Snack** - low fat yogurt (without added sugar), 125 mL - walnuts, 30 g	**Mid-morning Snack** - Greek yogurt (without added sugar), 150 mL (optional choice: a slice of bread with hazelnut cocoa cream, 20 g)	**Mid-morning Snack** - soy yogurt (without added sugar), 125 mL - walnuts, 30 g
Lunch - bread, 50 g - potatoes, 2 - tomato sauce, 20 g - seed oil, 10 mL - fruit salad (a fresh fruit + vegetable, 1)	**Lunch** - whole-grain cereals (such as spelt, rice, *or* whole-grain spaghetti), 100 g - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - walnuts *or* almonds, 30 g - fresh fruit, 1	**Lunch** - whole-grain cereals (such as spelt, rice, *or* whole-grain spaghetti), 100 g - nutritional yeast, 1 teaspoon - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1	**Lunch** - whole-grain spaghetti (*or* spelt, rice, *or* other whole-grain cereals), 90 g - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fruit salad with a fresh fruit + oat flakes, 30 g	**Lunch** - whole-grain cereals (such as spelt, rice, *or* quinoa), 100 g - nutritional yeast, 1 teaspoon - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1
Mid-afternoon Snack - fruit juice, 200 mL - sweet snack, 30 g	**Mid-afternoon Snack** - a slice of whole grain bread + extra virgin olive oil, 5 mL + fresh tomato, 1	**Mid-afternoon Snack** - a slice of whole grain bread + extra virgin olive oil, 5 mL + fresh tomato, 1	**Mid-afternoon Snack** - a slice of whole grain bread + Parmesan, 30 mL *or* dry-cured ham, 40 g	**Mid-afternoon Snack** - a slice of whole grain bread with sesame cream, 20 g *or* avocado, 60 g *or* extra virgin olive oil, 10 mL *or* dark chocolate, 30 g

Table A1. *Cont.*

Hypothetical Plan * for Western Diet	Hypothetical Plan * for Mediterranean Diet	Hypothetical Plan * for Flexitarian Diet	Hypothetical Plan * for Diet for Athletes	Hypothetical Plan * for 100% Plant-Based Diet
Dinner - spaghetti, 100 g - butter, 25 g - second course° such as cured meat, 40 g - 1 coke	**Dinner** - second course [I] (legumes, *or* fish, *or* white meat, *or* eggs, *or* occasionally red or cured meat) - three slices of whole grain bread - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1	**Dinner** - second course [II] (legumes, *or* tofu or tempeh, *or* cheese (cream or mature), *or* fish, *or* eggs, *or* occasionally meat) - three slices of whole grain bread - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1	**Dinner** - second course [III] (legumes, *or* fish, *or* white meat, *or* eggs, *or* occasionally red meat or cured meat) - three slices of whole grain bread - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1	**Dinner** - second course [IV] (legumes, *or* tofu or tempeh, *or* seitan) - three slices of whole grain bread - vegetables (raw or cooked), 200 g - extra virgin olive oil, 10 mL - fresh fruit, 1
Macronutrient and energetical contents: energy (E), kcal: 2.459 proteins (P), g: 97 fats (F), g: 105 carbohydrates (C), g: 303	**Macronutrient and energetical contents:** energy (E), kcal: 2.184 proteins (P), g: 71 fats (F), g: 81 carbohydrates (C), g: 314	**Macronutrient and energetical contents:** energy (E), kcal: 2.216 proteins (P), g: 70 fats (F), g: 83 carbohydrates (C), g: 317	**Macronutrient and energetical contents:** energy (E), kcal: 2.613 proteins (P), g: 116 fats (F), g: 78 carbohydrates (C), g: 386	**Macronutrient and energetical contents:** energy (E), kcal: 2.200 proteins (P), g: 71 fats (F), g: 83 carbohydrates (C), g: 314

* The five daily food plans for each dietary pattern were planned out considering an ideal subject (aged between 30 and 59; mean weigh, 69 kg; estimated caloric expenditure, 2.200 kcal) with no specific nutritional requirements owing to pathological or physiological conditions. The frequencies considered for the second course differed among the five dietary patterns: legumes, 50–60 g (raw) or 150–180 g (cooked)—frequency considered was twice a week or more I,III, three times/week II, or four times/week IV; fish, 120–150 g—frequency considered was twice a week or more I,III or twice a month II; white meat, 100–150 g—frequency considered was once/twice a week I,III or once/twice a month II; eggs, 2 or 100 g—frequency considered was once a week or less I,II,III; red meat, 100 g—frequency considered was once a week or less I,II,III; cured meat, 70 g—frequency considered was once per two weeks or less I,II,III; cheese, 100 g (cream cheese) or 50 g (matured)—frequency considered was once/twice a week II; tofu or tempeh, 100 g—frequency considered was once/twice a week II,IV; and seitan, 100 g—frequency considered was once a week II,IV. The frequencies estimated for the second course of the Western diet were: white meat, 100 g—more than twice a week; eggs, 2 or 100 g—once a week; red meat, 100 g—more than once a week; cured meat, 70 g—more than once a week; and cheese, 100 g (cream cheese) or 50 g (matured)—more than twice a week.

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