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A Comparison of the Mediterranean Diet and Current Food Consumption Patterns in Spain from a Nutritional and Water Perspective

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ABSTRACT

The promotion of responsible consumption is a key strategy to achieve environmental benefits, sustainable food security, and enhance public health. Countries like Spain are making efforts to reverse growing obesity and promote healthy diets, such as the recommended and traditional Mediterranean, recognized as a key strategy to improve the population´s health with locally grown, traditional, and seasonal products like fruits, vegetables, olive oil, and fish. With a view to connecting water, agriculture, food security, nutrition and health, this research aims to investigate and compare the nutritional and water implications of the current food consumption of Spanish households with the recommended Mediterranean diet. Besides, we calculate their nutritional composition, compare their water footprints, and develop a new methodological approach to assess nutritional water productivity (i.e. the nutritional value per unit of embedded water). Results show that the current Spanish diet is shifting away from the recommended Mediterranean towards an alternative one containing three times more meat, dairy and sugar products, and a third fewer fruits, vegetables, and cereals. The Mediterranean diet is also less caloric, as it contains smaller amounts of proteins and fats and is richer in fiber and micronutrients. Due to the high-embedded water content in animal products, a shift towards a Mediterranean diet would reduce the consumptive WF about 750 liters/capita day. Additionally, the Mediterranean diet has better water-nutritional efficiency than the current one: it provides more energy, fiber, and nutrients per liter of consumptive water. The study confirms the Mediterranean diet is a healthier and more sustainable diet with strong cultural heritage.

Keywords: Water footprint, dietary shifts, nutritional water productivity, water savings, water-use efficiency

1. Introduction

The world population is projected to increase to 9.7 billion in 2050 (United Nations, 2017). In order to achieve worldwide food security, food production will have to increase by 50% until 2050 (FAO, 2017). Many claim that measures designed to increase food production efficiency need, however, to be combined with policies and strategies aiming at improving food consumption patterns (Foley et al., 2011). The need to combine supply and demand management approaches is an embedded principle of the UN Sustainable Development Goals (SDGs). Of these, SDG 12 advocates responsible consumption (United Nations, 2015). Many authors have shown that a shift towards healthier diets may deliver multiple environmental benefits, including water savings (Blas et al., 2018, 2016; Donati et al., 2016; Vanham et al., 2018). Recent published work by the EAT–Lancet Commission on healthy diets (Willett et al., 2019) exhort shifting current dietary trends (which exacerbate people's and planet risks) to h **A Comparison of the Mediterranean Diet** ealthier diets from sustainable food systems by 2050.

In addition, for the first time in history, the majority of the world population now lives in cities (projected to be 68% by 2050) (United Nations, 2018). Urban consumers, particularly in the developing countries, account for a significant global shift in consumption from basic products (grains, fruits, and vegetables) towards higher-value (meat and dairy) and more processed foods (possibly containing high levels of fat, sugar or salt) (FAO et al., 2018). These shifts lead to increasing rates of diet-related chronic diseases (like cardiovascular disorders or diabetes) or to the global growth of obesity prevalence (672 million obese adults in 2017) (FAO et al., 2018). Likewise, preliminary research has been reported that could link nutrition, agriculture, and environment, e.g. the nutritional water productivity (NWP) concept by Renault and Wallender (2000). These authors defined NWP as the nutritional content of a crop per volume of water consumed, connecting crop productivity, food production, and nutrition by applying the water productivity concept to nutritional values. Nonetheless, research and methodological developments with respect their applications have not been taken further.

Countries like Spain are making significant efforts to reduce food waste, reverse growing obesity, and promote the adoption of healthier food habits like the recommended-traditional Mediterranean diet (Med_{Diet}). Promoting Med_{Diet} has been recognized as a key strategy to improve the population´s health with local, traditional and seasonal products like fruits, vegetables, olive oil, and fish (Bach-Faig et al., 2011a; Bonaccio et al., 2012), and has been recognized by UNESCO as a World Cultural Heritage (UNESCO, 2016). In fact, the Med_{Diet} is praised for having lower environmental impacts than others (Blas et al., 2016; Sáez-Almendros et al., 2013; Vanham et al., 2016). But current Spanish consumption patterns, especially among the younger and urban generations, are shifting towards more unhealthy diets (Bonaccio et al., 2012; Serra-Majem et al., 2004). These shifts are placing Mediterranean societies at high risk of obesity (Papandreou et al., 2008). Spain, in particular, is ranked among the top ten countries in the European region in terms of both adult obesity and overweight population (27% and 62% of the total population, respectively), and its prevalence is on the rise (WHO, 2013).

Water availability problems have been a historical issue in Spain, closely linked to growing water demand, particularly of agriculture, in a semi-arid climate setting (López-Gunn et al., 2012). Concepts like the water footprint (WF) or virtual water (VW) are gaining traction when trying to link water resource use and food production. This study compares the WF of two types of diets (identifying, thanks to a trade analysis, which proportion of WFs are national and which are imported). Consumed diets with lower WFs in this semi-arid context (where many problems regarding water management are related to irrigation water use) can be framed as a measure aimed to improve water's sustainability and lessening the pressure in already stressed water basins.

The main goal of this study is to provide a deeper understanding of consumers' behaviors and actual trends, by evaluating the shifting away of Spanish household's present consumption ($Current_{Diet}$), from the recommended-traditional Med_{Diet}. It compares their WFs (imported and local), and assesses the nutritional-health and nutritional water productivity (NWP) impacts of such shifting, to promote SDGs 2, 3, and 6, but especially SDG 12. Moreover, the study attempts to develop and create different databases, methodological approaches and inform policies that could link nutrition, diets, water, environment, and health, allowing for a better understanding of the relationship between food security, environment, and agriculture.

2. Materials and Methods

The methodology used in this study largely builds on Blas et al. (2018). Table 1 summarizes and describes data sources used for the composition, WF, nutritional and NWP analysis of both diets.

Table 1. Data description and sources

Dataset	Description	Characteristics	Source
Current food consumption	Estimation of actual household food consumption (Oct. 2014 - Sept. 2015)	Results from national household surveys (total consumption: 655 kg/capita year) broken down by food products (199) and assessed in previous research by Blas et al. (2018)	Spanish Ministry of Agriculture, Food and Environment (Ministerio de Agricultura Alimentación y Medio Ambiente, 2016a)
Mediterranean diet	Estimation of the Mediterranean diet in households (Oct. 2014 - Sept. 2015)	Assessment of the per capita consumption of the 199 products (kg/year) according to the recommended weekly servings of the traditional diet pyramid	Mediterranean Diet Foundation and its research studies (Bach-Faig et al., 2011a)
Nutritional values of food products	Multidimensional nutritional database	Nutritional value (energy, proteins, fats, carbohydrates, fiber, water, minerals and vitamins) per 100 g of each of the 199 consumed products	Spanish Agriculture Ministry and Spanish Nutrition Foundation databases (FEN, 2018)
Export and imports of food products	Database of food product import and exports (Oct. 2014-Sept. 2015)	Tons of the 84 most consumed products (70% of final current consumption) imported to Spain per year (and their origin) assessed in previous research by Blas et al. (2018)	Ministry of Economy and Competitiveness (Ministerio de Economía, 2016)
National food production	National production of every food product over a one-year period (Oct. 2014-Sept. 2015)	Tons/year of the 84 most consumed products (70% of final current consumption) produced in Spain assessed in previous research by Blas et al. (2018)	(Asemac, 2016; ASOZUMOS, 2016; FAO, 2015; INE, 2016; Ministerio de Agricultura Alimentación y Medio Ambiente, 2016b, 2016c; WPTC, 2016)
Water footprint of crop and livestock products	WF values of all food products (average time series 1996-2005)	Values for green, blue and grey WF in m^3/ton of all 199 agricultural and livestock products	(Mekonnen and Hoekstra, 2011, 2012)

2.1. Composition analysis

Data on current food consumption per household were collected for the period October 2014 to September 2015 and sourced from the Consumption, Commercialization and Food Distribution: Household Consumption Database Program (Ministerio de Agricultura Alimentación y Medio Ambiente, 2016a). This program surveyed a sample of 8,000 households of different sizes and income per capita, distributed over Spain, the average household size being estimated at 2.69 members. Data collection was based exclusively on daily note-taking on household food shopping, with a monthly sampling rate collected by an optical barcode reader. The dataset was analyzed by Blas et al. (2018), resulting in a total per capita consumption of 655 kg/capita year (i.e. kg/cy) broken down into 199 food products.

The Mediterranean diet in Spanish households was estimated again assuming that per capita consumption was 655 kg/cy, albeit with a different proportion of food product consumption, i.e., taking into account the food pyramid recommendations by the Mediterranean Diet Foundation and its research studies (Bach-Faig et al., 2011a). This pyramid describes the number of recommended servings of each food product and/or group per day (or week) in a traditional Mediterranean diet. For ease of assessment, food products (199 in total) were divided into 10 different groups. Bach-Faig et al. (2011a) describe the criteria for grouping these food items but refer mainly to the number of recommended servings per day/week as part of a Mediterranean diet. Food items like vegetables and fruits are grouped together not just because they are vegetable food products, but because the recommended daily intake is similar for both types of food items.

The groups, with their recommended weekly servings and the percentage of the total diet for which they account, were: (1) fruits and vegetables (70 servings, 41.5%); (2) cereals, olive oil and healthy drinks (52 servings, 31%); (3) olives, nuts, seeds and condiments (16 servings, 9.5%); (4) dairy products (14 servings, 8%); (5) eggs and legumes (6 servings, 3.5%); (6) fish and seafood (3 servings, 2%); (7) potatoes (2-3 servings, 1.5%); (8) white meat and vegetable fats (2 servings, 1.3%); (9) red or processed meat (1-2 servings, 1%) and (10) sugar, sweets, sauces and beverages (1 serving, 0.7%). Therefore, we assessed 168 servings per week equivalent to 24 per day and 8 per meal (breakfast, lunch, and dinner). To calculate the exact per capita consumption of each food product in Med_{Diet} (M_p) in kg/cy, we used Equation 1:

$$M_p = C_p \cdot R_{MD\,p} \tag{1}$$

where C_p is the current per capita consumption of a food product p (kg/cy) in the $Current_{Diet}$, and $R_{MD\,p}$ is the recommended percentage consumption of a product p in relation to the total diet according to the Med_{Diet} pyramid guidelines, as explained and detailed above.

2.2. Nutritional analysis

The nutritional analysis was conducted using data from the Spanish Ministry of Agriculture and Spanish Nutrition Foundation databases (FEN, 2018). Data for eight nutritional components were used for all food products within the diet (using information about similar products to estimate products with missing data). The eight analyzed nutritional values were: energy (kcal), proteins (g), fats (g), carbohydrates (g), fiber (g), water (g), minerals (mg) and vitamins (mg). Data on nutritional values were given per 100 grams of product. Total lipids were the sum of saturated, monounsaturated and polyunsaturated fatty acids, v-3, C18: 2 linoleic (v-6) and cholesterol. Minerals were the sum of calcium, iron, iodine, magnesium, zinc, sodium, potassium, phosphorus, and selenium. Finally, vitamins were the sum of: thiamine, riboflavin, niacin equivalent, vitamin B6, folates, vitamin B12, vitamin C, vitamin A (retinol), vitamin D and vitamin E. The multidimensional nutritional analysis was performed by multiplying each product´s nutritional value (N_p) and its consumption value: C_p for $Current_{Diet}$ diet and M_p for Med_{Diet}. The sum of all 199 products accounts for the nutritional diet value of both $Current_{Diet}$ and Med_{Diet}.

2.3. Water footprint for diets

Over the last few decades, several methodologies, including the water footprint assessment (WFA) (Hoekstra et al., 2011), and the life-cycle analysis (LCA) (Boulay et al., 2017; Hess et al., 2015; Pfister et al., 2017), have been developed to assess the impacts of food production and consumption patterns on water resources. Vanham et al. (2018) reported that the WF is an effective and valuable communication tool and a global methodological concept for raising consumer awareness about the water resources required to produce the food that we consume. They also reported how widely it is used in statements by different organizations, including recent official studies published by the European Commission (Gawlik et al., 2017). Yet, most of the studies published on diets and water impacts relied on the WF accounting (phase two of the WF Assessment), whereas less work applying an LCA approach has been published to date. Therefore, we use the WF accounting in this study (blue, green and grey), and the quantification of the pressure side of the WF; i.e., the consumptive use of green and blue water resources (Vanham et al., 2018).

We estimated the WF of the current food consumption and Mediterranean diet for Spanish households for the reference period from 1 October 2014 to 30 September 2015. Taking into account the proportion of nationally produced and imported consumed food (and the water needed to produce this food), we first estimate the volume of imported embedded water resources in Spanish household food consumption, relying on the global WF database of crops and livestock products (Mekonnen and Hoekstra, 2011, 2012). Both databases provide average worldwide values for the green, blue, and grey WF of all products (l/kg) for the time series 1996-2005. The WF is the result of the sum of these three components (Hoekstra et al., 2011). The green WF refers to rainwater stored in the soils and directly evapotranspired by crops. The blue WF refers to the volume of surface and groundwater embodied (i.e. evapotranspired) in the production of a good. Therefore, although a consumptive use of water, green WF is, as opposed to blue water, also a land-related concept. Finally, the grey WF is an indicator of water quality degradation and refers to the volume of freshwater required to assimilate the pollutant load generated throughout the product production chain in order to achieve the quality standards established in the environmental regulations (Hoekstra et al., 2011).

To discern the imported water volume, we analyzed the trade matrix of exports and imports of the most consumed food products (in terms of kilograms of annual consumption). In particular, we analyzed the origin of a total of 84 out of 199 products, which accounted for 70% of final household consumption. To determine the origin of these 84 most consumed food products, we used Spain's foreign trade multidimensional databases in the Datacomex platform (Ministerio de Economía, 2016). The annual trade data (aggregate monthly data from 1 October 2014 to 30 September 2015) specify tons of product imported to Spain per year and exporting country. Assuming that all the imported products were consumed in the diet (and the rest were produced nationally), we calculated a factor of net imports over net imports plus national production:

$$X_P = \left(\frac{I_p}{I_p + P_p}\right) \cdot 100 \qquad (2)$$

where X_p is the import factor of a product p (%), I_p is the total amount of net imports of a product p to Spain in a year from all countries, and P_p is the total Spanish national production of a product p in a year. To estimate the imported WF of each of the 84 most consumed products (IWF_p), we used the specific national data on WF contents (corresponding to each country of origin) and food product origin shown in Table 1. For products imported from just a few countries (i.e.

where 90% of the total product imports is concentrated in five countries), the IWF_p measured in liters per kilogram was calculated as follows:

$$IWF_P = \sum_{c=1}^{5} \left[\left(\text{Green WF}_{\text{p,c}} + \text{Blue WF}_{\text{p,c}} + \text{Grey WF}_{\text{p,c}} \right) \cdot \left({}^{\text{Y}_{\text{p,c}}} / {}_{I_p} \right) \right] \tag{3}$$

where, $Y_{p,c}$ is the total amount of a product p imported to Spain from country c (kg/y) and Green $WF_{p,c}$, Blue $WF_{p,c}$, Grey $WF_{p,c}$, are the green, blue, and grey WFs per product and country of origin (l/kg). On the other hand, for products whose imports are less concentrated (i.e. where 90% of product imports are spread across more than five countries), the IWFp was calculated using the international average WF values for a product p, as specified in the methodology applied by Blas et al. (2018). Finally, the WFs for current consumption ($WF_{Current}$) and Mediterranean diet (WF_{Med}) measured in liters per capita day (l/cd) were calculated using Equations 4 and 5, respectively:

$$WF_{Current} = \sum_{p=1}^{199} \left[(IWF_P \cdot X_P) + \left(NWF_P \cdot (100 - X_P) \right) \right] \cdot \text{C}_\text{p} \tag{4}$$

$$WF_{Med} = \sum_{p=1}^{199} \left[(IWF_P \cdot X_P) + \left(NWF_P \cdot (100 - X_P) \right) \right] \cdot \text{M}_\text{p} \tag{5}$$

where NWF_p is the Spanish national WF value (green, blue or grey) of a product p (l/kg), and, as defined above, C_p and M_p are the current and recommended Mediterranean diet consumption of a product p (kg/capita day), respectively.

2.4. Nutritional water productivity assessment

Nutritional water productivity (NWP) links water and nutrition. To calculate the green and blue NWP of each nutritional component n, for a diet i, we used:

$$NWP_{n\,i} = \sum_{p=1}^{199} \frac{(N_P \cdot F_P)}{\left[(I_P \cdot IWF_P \cdot X_P) + \left(P_p \cdot NWF_P \cdot (100 - X_P) \right) \right] \cdot H_i} \tag{6}$$

where N_p is the nutritional value per kilogram of a product p, F_p is the food consumption (C_p in $Current_{Diet}$ or M_p for Med_{Diet}) of a product p (kg/cy). As defined in Equation 2, I_P is the total imported value of a product p in a year (kg), P_p is the national production of a product p in a year (kg), and X_p is the import factor of a product p (%). IWF_p and NWF_p are the imported and national water footprints of a product p (l/kg) respectively, as explained in Equations 3 and 4. The green NWP was calculated using only green IWF_p and NWF_p values, and the blue NWP, using the blue IWF_p and NWF_p values. For the sake of consistency, we analyzed household food consumption only, applying the household consumption factor H_i. Accordingly, we only took into account the proportion of food that was consumed at home, excluding food consumed at restaurants, bars, or workplaces. For this analysis, H_i was estimated at 0.75 (75%), based on average data collected by the Spanish Ministry of Agriculture (Ministerio de Agricultura Alimentación y Medio Ambiente, 2016a) for the period 1987-2006.

3. Results

3.1. Diet composition

Figure 1 shows (a) the pyramid resulting from applying the recommended Med$_{Diet}$ to Spanish household consumption, following the guidelines of the Mediterranean Diet Foundation and its research studies (Bach-Faig et al., 2011a), and (b) their current food consumption. At the base of the Med$_{Diet}$ pyramid, there are two food groups, namely, fruits and vegetables, and cereals, olive oil, and healthy drinks. In contrast, the less consumed products appear at the top of the pyramid, namely, red or processed meat, and sugar, sweets, sauces, and beverages.

In current Spanish household consumption, fruit and vegetables account for only 26% of the total dietary intake (171 kg/cy, which is 100 kg less than in Med$_{Diet}$). Other food groups with lower consumption in the Current$_{Diet}$ compared with the Med$_{Diet}$ were: cereals, olive oil and healthy drinks (143.5 kg/cy, 60 kg less than in the Med$_{Diet}$), and olives, nuts, seeds and condiments (17 kg/cy, 44 kg less than in the Med$_{Diet}$). The higher consumption of dairy products (50 kg/cy more), sugar, sweets, sauces and beverages (86 kg/cy more), and red and/or processed meat (25 kg/cy more) accounts for the biggest disproportion between the food pyramids of the Current$_{Diet}$ and Med$_{Diet}$.

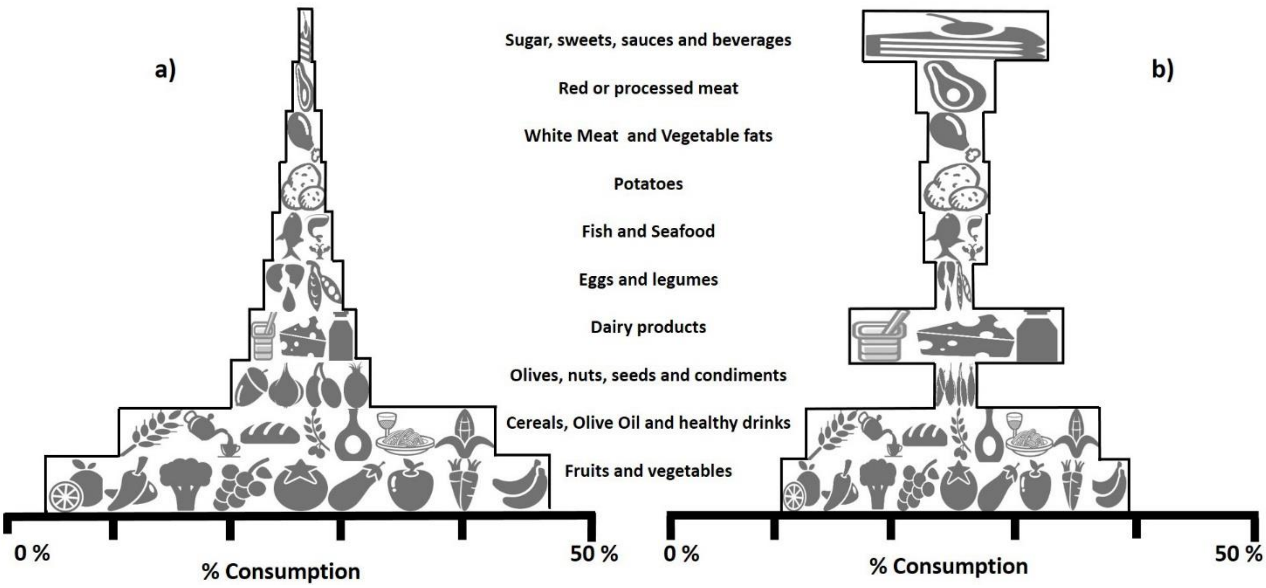

Figure 1. Diet composition divided into 10 food groups and their percentage of final consumption in Spanish households for a) estimated Mediterranean diet and b) current food consumption.

3.2. Nutritional Analysis

Multidimensional nutritional analyses of both the Current$_{Diet}$ and Med$_{Diet}$ are summarized in Table 2. They are calculated in terms of energy, proteins, fats, carbohydrates, fiber, minerals and vitamins for each food group (as well as their consumption in grams) per capita per day (cd). We find that the Med$_{Diet}$ is richer in fiber (52.5% more), minerals (33.5% more) and vitamins (70% more), and has lower levels of energy (15% less), proteins (32% less) and fats (27% less) than the

Current$_{Diet}$. The only nutritional component that is more or less unchanged in both diets is carbohydrates, although it is 1% higher in the Med$_{Diet}$. Looking at each nutritional component, Med$_{Diet}$ has fewer calories because of lower meat (white and red) and sugar, sweets, sauces, and beverages consumption. Animal origin food groups (dairy products and red/white meat), together with sugar and sweets, are also the main cause for higher proteins and fats levels in Current$_{Diet}$ compared with Med$_{Diet}$.

Regarding fats, the share of these four groups (dairy products, red and processed meat, white meat and animal fats, sugar, sweets, sauces and beverages) in the total Current$_{Diet}$ was 66 g/cd (64% of the total), whereas they account for only 19 g/cd (25% of the total) in Med$_{Diet}$. Within the fats group, cholesterol levels are half for Med$_{Diet}$ than for Current$_{Diet}$ (39 and 76 mg/cd respectively). Again, the main differences are rooted in foods of animal origin and the sugar food groups, that is, whereas these four groups accounted for 73% of total cholesterol levels (55 g/cd) in the Current$_{Diet}$, they represented only 41% (16 g/cd) in Med$_{Diet}$. On the other hand, higher values for fiber, water, minerals, and vitamins were observed in Med$_{Diet}$ mainly because of the higher consumption of fruits and vegetables, cereals, olive oil and healthy beverages and olives, nuts, seeds, and condiments. We should underscore that the minerals and vitamins levels of the sugar, sweets, sauces, and beverages group were 18 to 19 times lower in Med$_{Diet}$.

Table 2. Consumption values (grams/capita day) and multidimensional nutritional analyses (energy, proteins, fats, carbohydrates, fiber, minerals and vitamins) for each food group of the current consumption and Mediterranean diets in nutritional values per capita per day.

	CURRENT CONSUMPTION (CAP DAY)							
	Consumption (g)	**Energy (Kcal)**	**Proteins (g)**	**Fats (g)**	**Carbohydrates (g)**	**Fiber (g)**	**Minerals (mg)**	**Vitamins (mg)**
Sugar, sweets, sauces and beverages	249	382	4	17	53	1	428	135
Red or processed meat	89	231	18	17	1	0	946	8
White meat and vegetable fats	64	187	11	16	0	0	294	10
Potatoes	81	71	2	0	15	2	536	16
Fish and seafood	73	85	13	3	0	0	480	8
Eggs and legumes	44	64	5	3	4	2	282	5
Dairy products	285	257	15	16	14	0	1768	8
Olives, nuts, seeds and condiments	46	55	1	4	4	1	1703	161
Cereals, olive oil and healthy drinks	393	655	11	25	88	3	1068	6
Fruits and vegetables	470	195	5	2	37	8	1389	128
Total	**1794**	**2182**	**84**	**102**	**215**	**17**	**8894**	**485**
	MEDITERRANEAN DIET (CAP DAY)							
	Consumption (g)	**Energy (Kcal)**	**Proteins (g)**	**Fats (g)**	**Carbohydrates (g)**	**Fiber (g)**	**Minerals (mg)**	**Vitamins (mg)**
Sugar, sweets, sauces and beverages	13	20	0	1	3	0	23	7
Red or processed meat	19	48	4	4	0	0	199	2
White meat and vegetable fats	24	70	4	6	0	0	110	4
Potatoes	27	23	1	0	5	1	176	5
Fish and seafood	32	37	6	2	0	0	209	3
Eggs and legumes	64	92	7	4	6	3	406	8
Dairy products	149	134	8	8	7	0	922	4
Olives, nuts, seeds and condiments	167	198	5	13	13	5	6129	579
Cereals, olive oil and healthy drinks	557	928	16	35	125	4	1514	8
Fruits and vegetables	743	309	7	3	58	13	2195	203
Total	**1794**	**1860**	**58**	**75**	**217**	**26**	**11882**	**823**

3.3. Water footprint (WF)

Figure 2 shows the water footprint of Current$_{\text{Diet}}$ compared to Med$_{\text{Diet}}$. Clearly, all the components (green, blue, and grey) of the Current$_{\text{Diet}}$ WF were higher. The difference between the green WF of both diets is especially large: 2554 l/cd for Current$_{\text{Diet}}$ and 1835 l/cd for Med$_{\text{Diet}}$ (39% higher). This difference was mainly due to the Current$_{\text{Diet}}$ having a larger green WF for red or processed meats (434 l/cd higher than Med$_{\text{Diet}}$), sugar, sweets, sauces, and beverages (389 l/cd higher than Med$_{\text{Diet}}$), and dairy products (258 l/cd higher than Med$_{\text{Diet}}$). The differences between the blue WF of both diets were lower. Blue water use for the Current$_{\text{Diet}}$ was 34 liters more per capita per day than for Med$_{\text{Diet}}$. The largest differences were found in the sugar, sweets, sauces, and beverages and red or processed meats groups, which were 41 l/cd and 52 l/cd higher in Current$_{\text{Diet}}$ than in Med$_{\text{Diet}}$, respectively. Regarding the grey WF, the difference between both diets was 113 l/cd more for Current$_{\text{Diet}}$ than for Med$_{\text{Diet}}$ (48% higher). As with the other WF components, the dairy products, sugar, sweets, sauces, and beverages and red or processed meats food groups made the biggest differences.

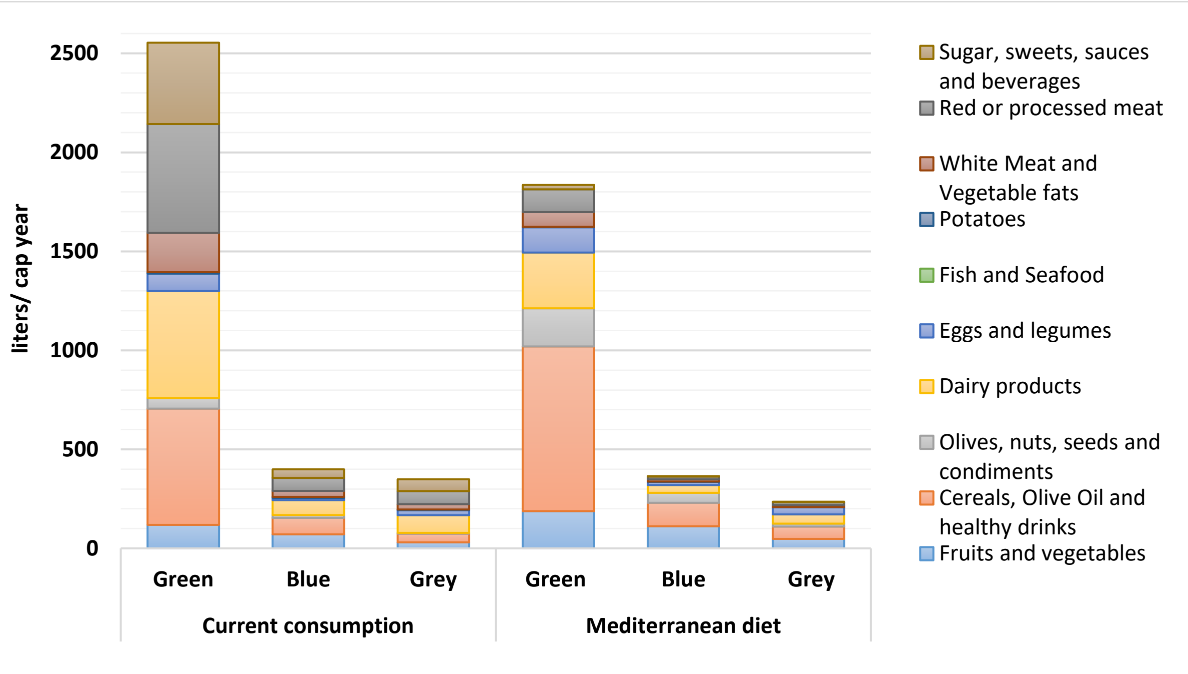

Figure 2. Water footprint (liters/capita day) divided by component (green, blue and grey) of Spanish household current consumption and the Mediterranean diet.

3.4. Nutritional Water Productivity (NWP)

Figure 3 shows the results of the NWP analysis for blue and green (consumptive use) water in both diets. Clearly, Med$_{\text{Diet}}$ was more nutritionally-water efficient than the Current$_{\text{Diet}}$ (for both green and blue) with respect to all eight nutritional components. The results show that, for the green NWP, Med$_{\text{Diet}}$ was highly efficient in vitamins (123% higher), followed by fiber, minerals and water (56, 55.5 and 52 % higher, respectively). Moreover, Med$_{\text{Diet}}$ was also very efficient for energy, proteins and carbohydrates water productivity values (around 39% higher than Current$_{\text{Diet}}$ for all of the above), and also, but lower, for the fats WP (25% higher than Current$_{\text{Diet}}$)

Values are similar for the blue NWP. In this case, Med$_{\text{Diet}}$ was very efficient in vitamins (175% higher than the Current$_{\text{Diet}}$), fiber (62% higher), minerals (55% higher), carbohydrates (46%), and energy and water (44% each higher). The less efficient values relate to proteins (38% higher) and fats (23%). On average, NWP values for blue and green water exhibited greater efficiencies with respect to all nutritional components for the food groups with a bigger share in $Med_{Diet,}$ i.e. fruits and vegetables, cereals, olive oil and healthy drinks, olives, nuts, seeds and condiments and eggs and legumes: 58%, 42%, 260% and 44% higher than for $Current_{Diet}$, respectively.

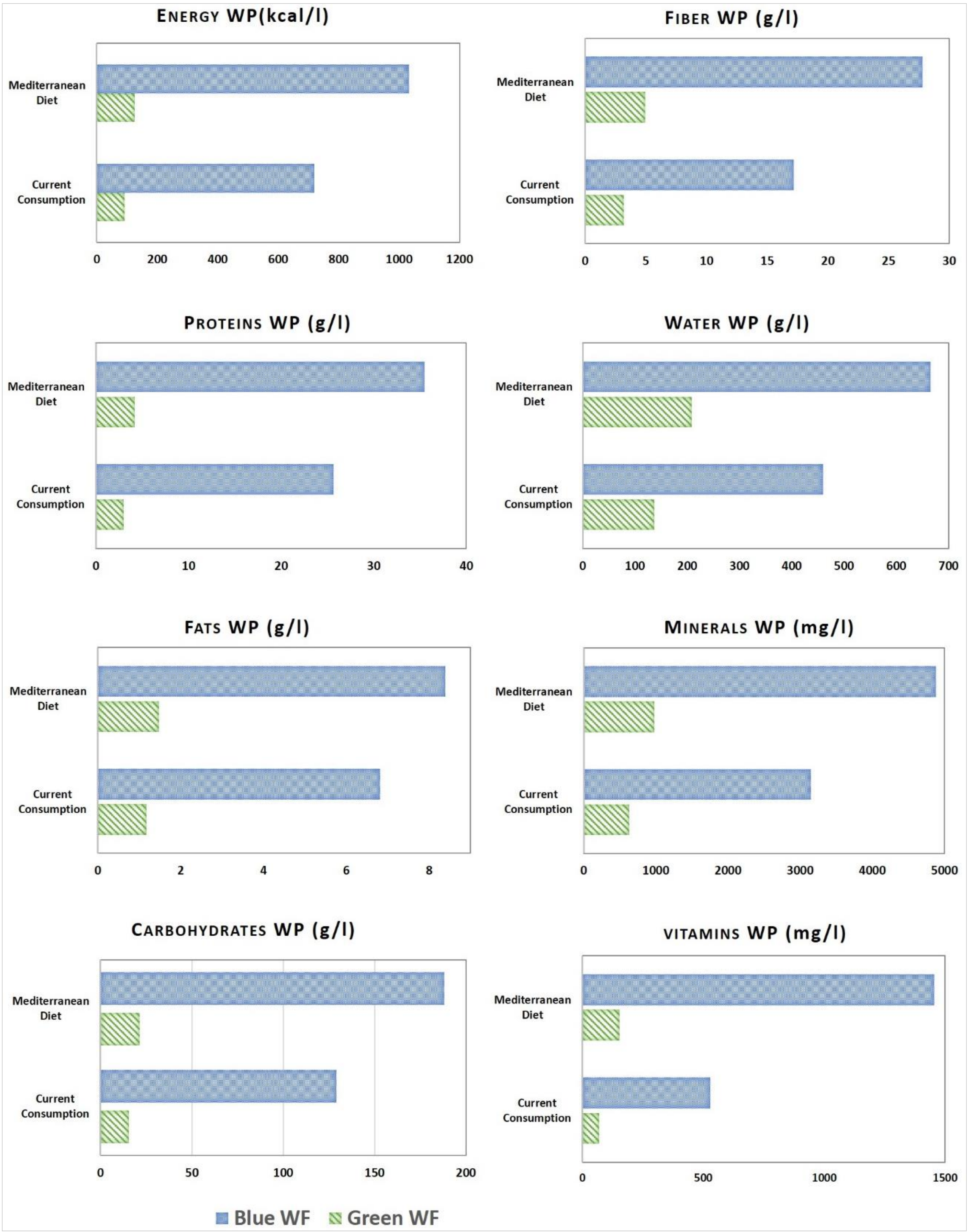

Figure 3. Nutritional water productivity (NWP) for blue and green water (consumptive use) in Mediterranean diet compared with current Spanish household consumption for all the nutritional components in nutritional values/liter of water.

4. Discussion

4.1. Consumption patterns

Over the last two decades, many studies within the Mediterranean region show that consumption patterns in countries like Spain, Italy and Greece are shifting towards more Western[1] and unhealthier diets (Bonaccio et al., 2012; Da Silva et al., 2009; Naska et al., 2006; Serra-Majem et al., 2004). Southern European countries are rapidly changing these patterns towards the consumption of more refined grains, animal fats, sugars and processed meats, and fewer legumes, cereals, fruits and vegetables (Bonaccio et al., 2012). Besides, other authors concluded that Mediterranean countries have increased meat consumption levels in recent years, even surpassing Northern European countries (Naska et al., 2006). Additionally, Da Silva et al. (2009) analyzed the worldwide trends of adherence to a recommended Mediterranean diet, comparing two periods (1961/65 and 2000/03), using FAO Food Balance Sheets. Over these 40 years, while Mediterranean countries experienced the greatest decrease in a Mediterranean-like dietary pattern, Northern European and some other countries (like Iran or Japan) were getting closer. In the case of Spain, Bach-Faig et al. (2011b) reported a progressive deviation from the traditional diet during the 1980s, then followed by stabilization and a slight recovery during the early 2000s.

In a study by Varela-Moreiras et al. (2010) analyzing Spanish household consumption from 2000 to 2006, the meat consumption level was higher than the analyzed Mediterranean recommended diet (65 kg/cy, 8% of total diet). Products, such as cereals (152 kg/cy, 10% of total diet), vegetables-potatoes-fruits (211 kg/cy, 25% of total diet), and legumes (5 kg/cy, 0.6% of total diet) were being consumed at levels below Med_{Diet} recommendations. Our results for $Current_{Diet}$ are in line with these findings, where the meat, dairy product, and sugar-sweet groups accounted for 39% of total consumption compared with 11% for Med_{Diet}. In other words, Spanish households have to reduce the intake of sugar, sweets, sauces and beverages by 86 kg/cy, red/processed meats by 25 kg/cy, white meat-vegetables fats by 15 kg/cy and dairy products by 50 kg/cy, and increase the intake of fruits-vegetables by 100 kg/cy, and cereals by 51 kg/cy to follow a recommended Med_{Diet}.

Varela-Moreiras et al. (2010) also concluded that some traditional staple foods like bread or olive oil showed a decline when compared with 1964 household surveys (Varela et al., 1971). Comparing our results with the 1964 findings, we also appreciate a decrease in consumption: bread from 134 kg/cy in 1964 to 35 kg/cy in 2014/15, and olive oil from 19 kg/cy in 1964 to 8.5 in 2014/15. We also find that, over the last 50 years (from 1964 to 2014/15), meat consumption increased from 28 to 55 kg/cy, dairy products from 83 to 104 kg/cy, and fish/seafood from 23 to 27 kg/cy. Instead, fruits-vegetables (potatoes included) decreased from 220 to 201 kg/cy. Nonetheless, meat and dairy product consumption decreased from 2000 (Varela-Moreiras et al. 2010) in comparison to our results of 2014/15.

Current consumption patterns have changed significantly over the last decades in Spain and other Mediterranean countries. In the case of Spain, Bach-Faig et al. (2011b) revealed that many socio-cultural and economic changes across the last few decades appear to be responsible for

[1] Western diet is a diet loosely defined as high in saturated fats, red meats, 'empty' carbohydrates—"junk food"—and low in fresh fruits and vegetables, whole grains, seafood or poultry (Segen, 2012).

this shift. After 1975, Spain underwent a rapid transition towards democracy and joined the EU, with increasing incomes, rapid urbanization, or technical improvements in the food industry. Another change was globalization, with its commercial, economic, regulatory, and technological and communication influences. Bach-Faig et al. (2011b) also reported other factors that significantly changed food demand and habits, such as female labor market participation, smaller household sizes, growing immigrant population, increased food consumption outside the home, Westernization of cooking habits and more leisure activities.

4.2. Nutritional analysis

According to our results, Med_{Diet} is less caloric (especially because it contains a smaller amount of proteins and fats) and has higher fiber, water, and micronutrient (vitamins and minerals) levels. Some studies established that depending upon demographic and other sociocultural factors, the energy intake for a healthy diet requirement ranges from 2,000 to 2,500 kcal/cd (SIWI, 2015) for an adult person. Other studies establish that an average daily per capita intake requirement is of the order of 2,000-2,200 kcal (Lundqvist and Unver, 2018). Our results showed that Med_{Diet} energy was 1860 kcal, while $Current_{Diet}$ was 2182 kcal. If we take into account that household food consumption accounted for only 75% of daily food intake, the results for energy level are 2325 kcal for Med_{Diet} and 2727 kcal for $Current_{Diet}$, supposing that the rest of the food intake is outside homes. Nonetheless, our results only assess the total food consumption resulting from household food shopping, so food waste values have to be subtracted from consumption values in order to assess the final food intake.

Many studies have considered Med_{Diet} as a healthy consumption pattern benchmark (Davis et al., 2016; Rosi et al., 2017) and compared the differences against other, not so allegedly healthy diets, like current Western patterns or meat-based diets, or with socioeconomic factors (Bonaccio et al., 2017). On the other hand, other studies also have made comparisons with other supposedly healthier diets, like a pescetarian, vegetarian, ovo-lacto-vegetarian, vegan, or even flexitarian (Springmann et al., 2018) diets. But what is a healthy diet? According to the World Health Organization (WHO, 2015), based on a previous study by the WHO Expert Committee (WHO and FAO, 2003), a healthy diet should be capable of helping to prevent all forms of malnutrition, as well as a range of diseases and conditions. For a healthy diet, WHO recommended: a) more than 400 grams of fruits and vegetables per person per day, b) a less than 10% share of sugar-sweets of total kcal, c) a 30% share of fats within total ingested kcal, and d) less than 5 grams of salt per person per day.

Our results showed that the Med_{Diet} fulfills three of these four requirements: 742 grams of fruits and vegetables, 1% of sugar and sweets within total kcal and less than 5 grams of salt per person per day (Med_{Diet} recommendations are to use garlic, onions and other natural spices instead of salt). On the other hand, $Current_{Diet}$ meets only two requirements: 468 grams of fruits and vegetables and 3.3 grams of salt per capita per day (which constitute worse values than for the Med_{Diet}). Finally, in terms of fats, neither diet meets the requirement: the fats share of Med_{Diet} and $Current_{Diet}$ was 36% and 42% of total kcal, respectively, where again Med_{Diet} was better positioned.

Looking at Spanish food consumption over the last few decades (Varela-Moreiras et al., 2010) in comparison with our results, we find that nutrition intake levels have changed. Varela-Moreiras et al. (2010) compared the contribution of alcohol and macronutrients to total energy consumption from 1964 (Varela et al., 1971) to 2006. Figure 4 compares these results with ours (current consumption and Mediterranean diet in 2014/15). The recommended Med_{Diet} food-nutritional values are between the 1964 and 1981 levels, i.e., the same patterns as Spanish household consumption 40 to 50 years ago. These results are consistent with findings reported by Bach-Faig et al. (2011b), concluding that Spain gradually deviated from the traditional diet as of the 1980s. The nutritional results of this study help to evaluate the direct and indirect correlations between the nutritional, health and environmental indicators of the Mediterranean diet (Dernini and Berry, 2015).

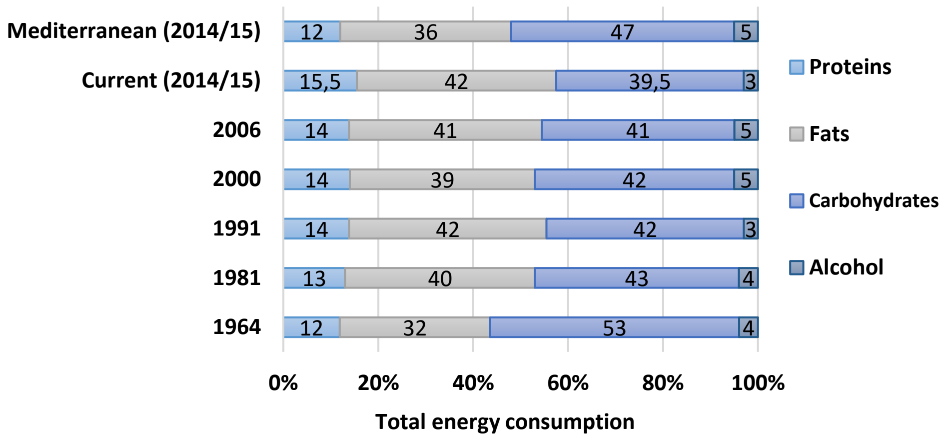

Figure 4. The share of proteins, fats, carbohydrates, and alcohol in the total energy consumption (%) for Spanish food consumption over the last decades (comparison of the data reported by Varela-Moreiras et al. (2010) and our results for current consumption and the Mediterranean diet in 2014/15).

4.3. Water footprints

Blue WF reductions of 34 l/cd can be achieved by adopting a Med_{Diet}. Taking into account that annual imported Blue water to Spain represented the 18% of the final Blue WF of $Current_{Diet}$ (using the data of Blas et al. 2018), nearly 28 l/cd (the 82%) of the blue water savings because of consuming a Med_{Diet} are Spanish blue water resources. Therefore, a widespread adoption of a Mediterranean diet by Spanish households would lead to net savings of Spanish blue water resources. In absolute terms (assuming a total population of 46.6 million people), these blue water savings translate into 474 million m^3 of Spanish national blue water resources that can be released and allocated to other uses.

A recent study by Hess and Sutcliffe (2018) reported worldwide hotspots (as Spain, the main fruits and vegetables export country to the UK, and particularly the Southeast Region of Murcia), where irrigated orchards for fruit and vegetable production (mainly for export) can produce environmental and economic negative impacts. Water savings in arid and semiarid regions of the main agricultural areas (Central, South and East of Spain; Andalucía, Valencia, Murcia…), because a change of diets, reduces the pressure on local water resources and has greater impacts that savings in humid regions. Indexes, like the Water Stress Index (WSI) (Pfister et al., 2009) or AWARE (Boulay et al., 2017), try to assess water scarcity at national or basin scales. Spanish regions have a Water Stress Index (WSI) above 0.6 (Ridoutt and Pfister, 2010), which mean high (>0.4) and very high (>0.8) water stress (Hess et al., 2015), especially the southern ones, like Andalucía and Murcia (>0.9). Similar values appear with AWARE Index, where

Southern and East Spanish regions have a factor ranging 60-100 (the maximum) and the rest ranging between 10-60 (being 0.1 the minimum) (Boulay et al., 2017).

Some consequences of regional impacts (in the most important agricultural regions in Spain, most of them with arid or semiarid conditions) because of Blue water savings adopting a Med_{Diet} can be seen in Table 3. This table shows the regional water footprint (data from the study of Willaarts et al., 2016) and the reduction of the irrigation of Blue WF, resulting from embracing the Med_{Diet} and reversing food consumption habits. Although in percentage terms the reductions are low (1-8%), they represent savings that would match between 50 and 100% the expected reductions of run-off resulting from climate change for 2040 (CEDEX, 2017).

Table 3. Blue regional and national Irrigation WFs (million m^3) from Willaarts et al., (2016) and reductions adopting a Mediterranean Diet (474 million m^3) in % over regional Blue WFs.

Region	**Population**	**Blue WF**		
		Irrigation Total WF (million m^3)	**Reductions with Med_{Diet} 27. 8 (l/cd)**	
			(million m^3)	**(% of total Blue WF)**
Andalucía	8399043	4046	85	2%
Aragón	1317847	1511	13	1%
Castilla La Mancha	2059191	1627	21	1%
Castilla and León	2472052	1806	25	1%
Cataluña	7508106	993	76	8%
C. Valenciana	4980689	1402	51	4%
Extremadura	1092997	1265	11	1%
Murcia	1467288	600	15	2%
Total Spain	**46624382**	**13846**	**474**	**3%**

Another angle from which the results can be assessed is by looking at the last national study on the supply of drinking water and sanitation in Spain during 2017 (AEAS and AGA, 2018). Total water use in Spanish households (drinking, washing, cooking, toilet, shower, cleaning…etc.), was, in average; 132 l/cd. The potential saving by adopting a Med_{Diet} (nearly 28 l/cd of national irrigation water) equals around 21% of the other entire personal consumptive domestic purposes. In other words, 5 days eating a Med_{Diet} is equivalent to one day all water uses.

Finally, our results are consistent with findings concluding that a Mediterranean diet have lower WFs compared with other Western meat-based dietary patterns (Blas et al., 2016; Davis et al., 2016; López-Gunn et al., 2012; Sáez-Almendros et al., 2013). The products that accounted for the largest share of WFs were of animal origin: they accounted for the final 50% (1641 l/cd) of total WF in $Current_{Diet}$, as opposed to only 606 liters/cd in the Med_{Diet} (25%). So the results are also consistent with findings suggesting that diets based on legumes, vegetables and fruits lead to larger water savings (Jalava et al., 2014; Marlow et al., 2009; Vanham et al., 2013a, 2013b).

4.4. Nutritional water productivity (NWP)

A few years after the NWP concept was developed by Renault and Wallender (2000), the Stockholm International Water Institute (SIWI and IWM, 2004) promoted the "More Nutrition per Drop" strategy, going beyond the previous motto "More Crop per Drop", especially to the population with nutritional problems. Renault and Wallender (2000) also reported that a water-food link is crucial for nutrition and livelihood security in poor rural communities. In the past, some studies have been conducted to analyze dietary energy and water or water use related to protein content (Gephart et al., 2014; Jalava et al., 2014). Even so, more research is needed to highlight the need to link water use in agriculture with food and nutrition security and improve human health.

Wenhold et al. (2012) applied the NWP index to study the water use and nutrient content of food products in South African households. In a recent review about the water-food-nutrition-health nexus, Mabhaudhi et al. (2016) concluded that NWP is the most useful index to address agricultural water use impacts in food and nutrition security. They also deduced that it is essential to promote this kind of metrics to improve human nutrition and health in poor rural communities. Moreover, the United Nations Food and Agriculture Organization (FAO) has been working over the last few years to develop the NWP methodology and link water and agricultural strategies to improve food security and nutrition. It follows a strategy to enhance awareness about the linkages between water and nutrition and achieve nutritional and health-related SDGs.

Nevertheless, literature about NWP in food products and diets is still limited. Moreover, the methodological approach used in this study has new and different dimensions, components and applications, and our results are hard to compare with others. We applied Renault and Wallender's NWP concept to diet composition, taking into account national production and imports and quantifying the WFs.

With one liter of irrigation water (Blue WF) in the Mediterranean diet, the consumer obtains; 1033 kcal, 231 grams of macronutrients and 6.3 grams of micronutrients, while only; 720 Kcal, 162 grams of macronutrients and 3.7 grams of micronutrients in the current consumption diet. Similar values are observed for the green NWP (Figure 3). As already highlighted by earlier studies (Renault and Wallender, 2000; Wenhold et al., 2012), a greater proportion of animal products – meat and dairy -- with large water footprints make diets significantly water-nutrient inefficient, even though they are relatively rich in nutrients like protein or fats. These means that a) more water is needed to obtain the same level of nutrients if Current Consumption is consumed, and b) the Mediterranean Diet fits in the "More Nutrition per Drop" (and hence to a more sustainable diet), a strategy promoted these last years by institutions like SIWI and FAO.

4.5. Limitations and further research

Some of the limitations of the WF values provided for animal (Mekonnen and Hoekstra, 2012) and crop (Mekonnen and Hoekstra, 2011) products are: 1) limited information on the location of the irrigated areas within the countries; 2) lack of detailed (sub-national) information on harvesting dates for the different crops; 3) irrigation water demand assumptions. The lack of detailed information or simplify assumptions is a source of uncertainty, which will require further assessment.

In the case of Spain, previous studies have found that WF crop estimations can differ significantly using more disaggregated data (Garrido et al., 2010). Local climate variability and agricultural practices can have large effects on the WF for agricultural products (Blas et al., 2018). Also, irrigation practices differ widely among crops, and it is often the case, particularly for cereals, that irrigation water requirements are not fully met, and farmers apply the so-called "deficit-irrigation". The wide range of estimations for the same products and countries requires detailed comparison of the values reported by Mekonnen and Hoekstra and the ones used in this research and other national-local studies.

Further research would be needed in order to assess more environmental, social, and economic impacts of the shifting away that Spanish consumers are doing from the traditional and endemic Mediterranean Diet. Also using other methodological approaches to try to assess water scarcity at national or basin scales, different and beyond WF accounting, e.g., LCA, ISO 14046, (Boulay et al., 2017; Pfister et al., 2017), indexes like WSI or AWARE (Hess et al., 2015; Hess and Sutcliffe, 2018), or even studying how production practices do indeed matter for blue water savings (Poore and Nemecek, 2018). Finally, the multiple datasets required for this study highlight the difficulties of estimating national food consumption and trade, and denote how challenging it is to inform policies tackling sustainable food consumption and their relation to water management. Because of this difficulty, we have only assessed one-year data (with respect to imports and not exports or re-exports) with the resulting limitations.

5. Conclusions

A change in dietary patterns towards a more Western and unhealthy diet is being observed in Mediterranean countries. Our research shows that the current food consumption patterns of Spanish households are shifting towards diets containing more meat, dairy and sugar products, and fewer fruits, vegetables and cereals. The recommended Mediterranean diet is less caloric, especially because it contains lower amounts of proteins and fats than the current consumption trends and has higher fiber, water, and micronutrients (vitamins and minerals). This traditional diet is better adapted to the parameters of the World Health Organization's healthy diet recommendations than the current food consumption observed in Spain in present times. Moreover, its consumption and nutritional values are consistent with the patterns of Spanish household consumption 40 to 50 years ago, while the current pattern follows the trend initiated in the 1980s, with a higher percentage of proteins and fats and fewer carbohydrates.

This article highlights the benefits linked to embracing the Mediterranean diet not just because of its potential health benefits, but also because it is a less water-intensive diet. Because the products that accounted for the largest share of WFs were of animal origin: meats, animal fats and dairy products, consumptive WF can be reduced by 753 liters per person per day (of which 34 are Blue WF, and 28 l/cd from Spanish blue water resources), if a Mediterranean diet replaced current food trends. This is relevant for semi-arid countries, like those with Mediterranean climate. Lastly, our results showed that the Mediterranean diet has a better water-nutritional efficiency than current consumption: more energy, fiber, and macro- and micronutrients are available per liter of consumptive water use. Although some studies have been carried out over the last few years, further research is required to assess the nutritional water productivity of food products in order to obtain more accurate estimations of the water-nutrition-health nexus.

The Mediterranean diet optimizes water resources and is a more nutritionally adequate, and healthier diet, being more sustainable than current Spanish consumption.

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