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ORIGINAL RESEARCH PAPER

MEDITERRANEAN DIET PYRAMID OF AN ADULT MOROCCAN POPULATION: COMPARISON WITH THE RECOMMENDATIONS OF THE UPDATED MEDITERRANEAN DIET PYRAMID

IMANE BARAKAT, HAMID CHAMLAL, HOUDA EL FANE, SANAA EL-JAMAL, MOHAMMED ELAYACHI, REKIA BELAHSEN*

Laboratory of Biotechnology, Biochemistry and Nutrition, School of Sciences – ChouaibDoukkali University – El Jadida – 24000 – Morocco.

*Corresponding author: b.rekia@gmail.com; rbelahsen@yahoo.com

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Abstract

One of the illustrations selected for the presentation of the nutritional recommendations of the Mediterranean diet (DM) is the food pyramid (FP). The aim of this work was to design a food pyramid illustrating the dietary pattern of an adult Moroccan population and compare it to the recommendations of the Mediterranean diet pyramid (MDP) updated in 2020 by a group of experts. The study was carried out over the period of 2018 to 2022, on 507 adults from the Rabat-Salé-Kenitra region in Morocco. Socio-demographic data, usability, and toxic habits were collected using a questionnaire. Physical activity was assessed by the Marshal questionnaire. Food intake and food diversity have been determined by food history and food variety by food frequency questionnaires. The majority of the study population was over 34 years old (59%), resides in urban areas (70%), of which women (52%), sufficiently active (57%) and without any toxic habits (99.9%). A proportion of 31% still participate in meal preparation within the household, and 48.9% have at least two meals with the family daily. The population's energy and protein intakes are higher ($p<0.001$) while their dietary fiber and water intakes are lower than the recommended intakes ($p<0.001$). The FP constructed according to the population's food consumption comprises, from the bottom to the top, 1) water, 2) cereals and starchy foods, 3) sugars and sweet products, 4) fruits and vegetables, 5) dairy products, 6) olive oil, and 7) pulses, dried fruits, red meat, fish, chicken, eggs, and olives. The hierarchy and frequency of the consumption of certain foods and food groups differ from the recommendations of the updated MDP, reflecting a shift from sustainable diet.

Keywords: food pyramid, Mediterranean diet, dietary diversity, dietary variety, lifestyle, nutritional recommendations

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Introduction

Societies in both developed and developing countries have undergone lifestyle changes in the recent decades, characterized by an increase in sedentary lifestyles and the adoption of unhealthy diets, resulting in public health issues such as malnutrition, overweight, obesity, metabolic syndrome and kidney disease (Belahsen, 2014; Barba-Orellana *et al*., 2020; Salas-Salvadó and Papandreou, 2020). One of the important aspects to remedy this alarming situation is an adequate diet of improved quality that takes into account respect for the environment and food sustainability (Salas-Salvadó and Papandreou, 2020; Willett *et al*., 2019) in addition to a healthy lifestyle (Bach-Faig *et al*., 2011; Saulle and La Torre, 2010), including physical activity, conviviality and the fight against substance abuse.

Mediterranean diet (DM) is a sustainable dietary pattern recognized for health benefits, prevention of chronic diseases, reduction of public health costs, and improvement of overall well-being (Benyaich, 2017; Dernini *et al*., 2017; D'Alessandro and De Pergola, 2018). It is the healthiest food model because of its food diversity, the balance between energy intake and needs, the consumption of minimally processed tubers, legumes; fruits and vegetables, seeds and unsalted nuts, fish and seafood, vegetable fats with a good omega 3/omega 6 ratio, preference of water to soft drinks, as well as a moderate consumption of meat and dairy products, as well as a very limited consumption of foods high in fat, sugar, and salt (Gonzalez Fischer and Garnett, 2018). Additionally, the health benefits of MD have been linked to its intake of low glycemic index carbohydrates, dietary fiber, unsaturated fatty acids, antioxidants, and anti-inflammatory compounds (Renna *et al*., 2021). DM is further characterized by freshness, variety, frugality, and palatability or appetizing taste (Salas-Salvadó and Papandreou, 2020).

One of the illustrations used for the presentation of the DM is the food pyramid (FP), a visual object for communicating nutritional recommendations, whose persistence seems to be explained by its cognitive relevance (Kovacs and Orange-Ravachol, 2015). The notion of FP, conceived for the first time in 1993 (Willett *et al*., 1995), has evolved over time with updates in 2009 and 2010, taking into account scientific evidence considering the challenges related to lifestyle, diet, socio-cultural aspects, environment and health. It was adapted to different cultural and socio-economic contexts of the countries of the Mediterranean region (Bach-Faig *et al*., 2011), suggesting the types and frequency of foods that should be consumed every day (Salas-Salvadó and Papandreou, 2020). On the other hand, the Mediterranean diet pyramid (MDP) updated in 2020 by a group of experts has integrated, in addition to the nutritional aspect, lifestyle, conviviality, additional information on regional food traditions, as well as the transformation of food systems for a healthier and more sustainable model (Serra-Majem *et al*., 2020). In addition, and compared to the previous version of 2011 (Bach-Faig *et al*., 2011), this MDP placed more emphasis on lower consumption of red meat and bovine dairy products, and higher consumption of legumes and plant foods, which are locally grown and environmentally friendly (Serra-Majem *et al*., 2020). The new

pyramid is the result of international consensus and is based on the latest scientific evidence in the field of health and nutrition, published in hundreds of scientific articles in the last few decades (Dernini *et al*., 2012).

In this work, we first aspire to have a pyramid representation illustrating the dietary model with its components for an adult population, and then compare it to the updated MDP of 2020 (Serra-Majem *et al*., 2020) in order to detect foods to be more or less frequently consumed.

Materials and methods

This study was conducted between 2018 and 2022 on an adult population in the Rabat-Salé-Kénitra (RSK) region of Morocco (Barakat *et al*., 2022), specifically in the prefectures of Rabat, Salé, Skhirate-Témara, and the provinces of Kenitra, Khemisset, SidiKassem and SidiSlimane.

Sampling

A two-stage random sampling method was adopted. First, 28 urban and rural neighborhoods were randomly selected from the seven prefectures and provinces of the RSK region, and second, 507 adult people to whom questionnaires were administered were recruited.

Data collection

Socio-demographic, usability, frugality, and toxic habits data were collected through a questionnaire; physical activity was assessed through the Marshal questionnaire (Inserm, 2014; Marshall *et al*., 2005); data on nutritional intakes and food diversity were collected by a food-history-type survey (Dufourny *et al*., 2008; Rutishauser, 2005); and the food variety was determined by a food frequency questionnaire (Rutishauser, 2005).

Variables studied

Socio-demographic characteristics, such as age groups of 1) 20-34 years, and 2) ≥ 35 years, and the residency setting categorized as 1) urban, and 2) rural areas.

Physical activity was categorized as 1) sufficiently active, and 2) insufficiently active.

Toxic habits[1] are categorized as 1) use of tobacco, and 2) not.

Conviviality was studied by participation in meal preparation and by commensality (Bricas, 1998). Participation in meal preparation is categorized as 1) never, 2) rarely, 3) often, and 4) always. Family commensality[2] is categorized into 1) weekends only, 2) one meal per day, and 3) ≥ 2 meals per day.

The nutrient intakes determined were energy (kcal/day), protein (g/day), carbohydrate (g/day), fat (g/day), dietary fiber (g/day) and water (ml/d/d).

[1]Respondents reported that they usually do not drink alcoholic beverages. Therefore, we have retained the responses on smoking.

[2]In this work, family commensality means taking meals at the same table and at the same time as the family without necessarily eating in the same dish, as is the custom in Morocco.

The dietary diversity was determined by the frequency of the consumption of six food groups, including the cereals and starches group, the fruit and vegetables group, the milk and milk products group, the meat-fish-eggs group (M-F-E), the fatty substances group, and the sugar and sweet products group (Maillot *et al*., 2007; Ministère de la Santé (Maroc), 2016). It is categorized into 1) ≥ 3 portions per day, 2) 2 portions per day, 3) 1 portion per day, 4) 4 to 6 portions per week, and 5) 1 to 3 portions per week.

The food variety was assessed using the frequency of consumption of the foods listed in the updated MDP (Serra-Majem *et al*., 2020). This frequency is categorized into 1) < 1 portion per month, 2) 1-3 portions per month, 3) 1-3 portions per week, 4) 4-6 portions per week, and 5) ≥ 1 portion per day.

Analyses

The diversity of food groups consumed was analyzed by Excel software, and the population's socio-demographic characteristics, as well as food variety, were analyzed by SPSS version 21.

A descriptive statistical analysis was conducted to characterize the study population. To do this, numbers and percentages were used for qualitative variables, and medians (quartiles) for quantitative variables, because all of them have an asymmetric distribution.

The Pearson test was used to compare the dietary intakes of the studied population to the dietary reference intakes (DRI) with a significance threshold of $p \leq 0.05$.

Ethical considerations

The study was authorized by the Wilaya and the Regional Health Directorate of the Rabat, Salé, Kenitra (RSK) region. The basic ethical principles governing the conduct of the research were followed, including informing participants about the study subject, volunteering, confidentiality, and the right to withdraw from the study at any time. Free and informed prior consent was obtained from study participants.

Results

Socio-demographic characteristics, lifestyle, and conviviality

Table 1 shows that the majority of the studied population was over 34 years old (59%), resided in urban areas (70%), was women (52%), they were sufficiently active (57%), and had no toxic habits (90.9%). About half of the study population eat at least two meals a day with their families (48.9%) and a third (31%) was usually involved in preparing meals in the household. The population dietary intakes averaged 2065 kcal/day for energy, 67 g/day for protein, 290 g/day for carbohydrates, 72 g/day for fat, 21 g/day for dietary fiber, and 1564 ml/day for water intake.

Table 1. Socio-demographic characteristics, lifestyle, and conviviality (n=507).

Characteristics	Value	CI (95%)
Socio-demographic characteristics		
Age(years)*		
- [20 – 34]	210 (41%)	[36.7- 45.8]
- ≥35	297 (59%)	[54.2 - 63.3]
Residence Area*		
- Urban	355(70%)	[66-74]
- Rural	152(30%)	[26-33]
Gender*		
- Man	244 (48%)	[43.6 - 52.3]
- Woman	263 (52%)	[47.7 - 56.4]
Lifestyle		
Dietary intakes**		
- Energy (kcal/day)	2065 [1784 ; 2563]	-
- Proteins (g/day)	67 [53;85]	-
- Carbohydrates (g/day)	290 [237; 356]	-
- Fats (g/day)	72 [57;89]	-
- Dietary fibers (g/day)	21 [17;25]	-
- Water (ml/day)	1564 [1190 ; 1863]	-
Physical activity*		
- Sufficiently active	291 (57%)	[52,9-61,9]
- Insufficiently active	216 (43%)	[38,1-47,1]
Toxic habits*		
- Yes	46(9.1%)	[6.5-11.8]
- No	461(90.9%)	[88.2-93.5]
Participation in the meal preparation and family commensality		
Participation in meal preparation*		
- Never	94(18.5%)	[15.4-21.9]
- Rarely	134(26.4%)	[22.5-30.4]
- Often	122(24.1%)	[20.5-27.6]
- Always	157(31%)	[27-35.1]
Family commensality*		
- Only on weekends	43 (8.5%)	[6.1-11]
- 1 meal/day	216 (42.6%)	[38.3-46.7]
- ≥ 2 meals/day	248 (48.9%)	[44.6-53.6]

*= Expressed as numbers (percentages %); ** = Expressed as median (Quartiles); CI= Confidence Interval; g= gram; ml= milliliter

Comparison of dietary intakes of the study population to dietary reference intakes (DRI)

Table 2 shows that, compared to the DRI, the studied population had excessive consumption of energy (+3.25%), protein (+34%), carbohydrates (+11.5%) and fat (+2.8%). Consumption of dietary fiber (-16%) and water (-32%) was lower, all very different from DRI ($p < 0.001$).

Table 2. Comparison of dietary intakes to dietary reference intakes (n=507).

Dietary intakes	Nutritional intakes of the studied population*	Dietary reference intakes	Variation (%)	P
Energy (kcal/day)	2065 [1784; 2563]	2000**	+3.25%	<0.001*****
Proteins (g/day)	67 [53;85]	50**	+34%	<0.001*****
Carbohydrates(g/day)	290 [237; 356]	260**	+11.5%	<0.001*****
Fats (g/day)	72 [57;89]	70**	+2.8%	<0.001*****
Dietary fibers (g/day)	21 [17;25]	25***	-16%	<0.001*****
Water (ml/day)	1564 [1190;1863]	2000****	-32%	<0.001*****

*= Expressed as a median (Quartiles); **=(Journal Officiel de l'Union Européenne, 2011); ***= (Medicine Institute of Dietary Reference, 2002); ****= Institut Français pour la Nutrition (IFN, 2004); *****= Significant difference; P = Pearson test with a significance threshold p≤0.05; g= gram; ml= milliliter.

Diversity of food groups

Figure 1 shows that the study population had the habit of consuming one portion per day from the dairy group (39%) and from the M-F-E group (46%), two portions from the sugar and sweet group (70%) and from the vegetables and fruits group (64%), and at least three portions per day from the fats group (58%) and from the cereals and starch group (100%).

Food variety

Table 3 shows that the majority of the respondents consume one to three portions per week of pulses (80.3%), dried fruits (87.2%), red meat (56%), fish (83.8%), chicken (45.5%), eggs (42%), and olives (69.8%). Four to six portions per week of olive oil were also consumed (46.2%), at least one portion per day of vegetables (58%) and fresh fruit (65.9%).

Figure 2 shows that regarding food diversity, cereals and starches are at the basis of the FP with a consumption of ≥ 3 portions per day, followed by sugar and sweet products with a consumption of 2 portions per day, vegetables and fruits with a consumption ≥ 1 portion per day, followed by dairy products with a consumption of one portion per day; then olive oil with 4 to 6 portions per week, and the pulses, dried fruits, red meat, fish, chicken, eggs, and olives groups with a daily intake of one to three portions. Regarding lifestyle, there is excessive energy and protein intake, deficient dietary fiber and water intake, sufficient physical activity, and rare toxic habits. Regarding conviviality, frequent participation in the preparation of meals and eating of family meals was noted.

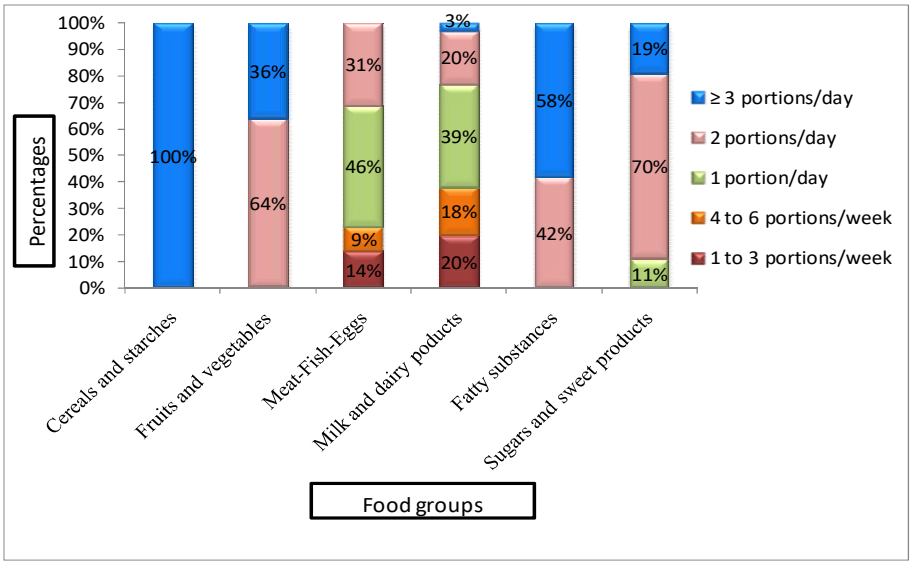

Figure 1. Distribution of food groups according to the number of portions consumed by the studied population (n=507).

Table 3. Food variety in the studied population (n=507).

Foods*	Frequency of food consumption				
	Monthly consumption		Weekly consumption		Daily
	< 1 p/m	1 - 3 p/m	1- 3 p/w	4 - 6 p/w	≥ 1 p/day
Pulses	60(11.8%)	40(7.9%)	407(80.3%)	-	-
Vegetables	-	-	-	213(42%)	294(58%)
Fresh Fruits	-	-	173(34.1%)	-	334(65.9%)
Dried Fruits	-	29(5.7%)	442(87.2%)	-	36(7.1%)
Red meat	50(9.9%)	27(5.3%)	284(56%)	95(18.7%)	51(10.1%)
Fish	50(9.9%)	32(6.3%)	425(83.8%)	-	-
Chicken	94(18.5%)	182(36%)	231(45.5%)	-	-
Eggs	132(26%)	137(27%)	213(42%)	-	25(5%)
Olive oil	-	12(2.4 %)	197(38.9%)	234(46.2%)	64(12.6%)
Olives	-	-	354(69.8%)	47(9.3%)	106(20.9%)

*= Expressed as numbers (percentages %); p= portion; m= month; w= week.

Discussion

The Mediterranean diet has attracted much attention and interest because of its beneficial effects on health in comparison with other diets in the world (Sarri and Kafatos, 2005). It has been the subject of abundant research on its food components (Benjelloun, 2011; Salas-Salvadó and Papandreou, 2020). However,

there are a variety of diets in the Mediterranean countries that differ according to geography, history, religion, and culture. The diet is represented graphically by a pyramid as a dietary guideline with a composition that includes the consumption of water, cereals and pulses, vegetables and fruit, milk and milk products, meat, fish, eggs, fats, sugars, and sweet products, but also other non-food components such as lifestyle, friendliness, and sustainability (Bach-Faig *et al.*, 2011; Kovacs and Orange-Ravachol, 2015). Indeed, with the advent of economic development, urbanization, and lifestyle changes including diet, the epidemiological profile has been accompanied by several non-communicable diseases that are emerging and increasing globally, including in the Mediterranean countries (Benjelloun, 2011; Belahsen, 2014; Barba-Orellana *et al.*, 2020; Salas-Salvadó and Papandreou, 2020), raising the question of the sustainability of this diet on health. These changes also revealed the remoteness or decline in adherence to this traditional regime as a model.

Figure 2. The study population food pyramid (n=507).

In this study, a graphical representation is designed concerning the diet of a Moroccan population of adults, women and men, residing in urban and rural areas, considering different socio-demographic characteristics because factors that are

likely to influence their eating practices (Rastoin and Ghersi, 2010; Boussoco *et al*., 2016), including food consumption. Indeed, it has been reported that urban residence (Benjelloun, 2011) and young age are associated with modern dietary behaviors (Dernini *et al*., 2017), while rural residence (Benjelloun, 2011) and older age (Recours and Hebel, 2007) are rather associated with traditional dietary practices. In addition, the heterogeneous socio-demographic profile of a population could affect the type of its food consumption, lifestyle, and user-friendly habits (Barakat *et al*., 2020). Moreover, the recommended MDP (Serra-Majem *et al*., 2020), targeting the adult population aged 18 to 65, was conceived as a pyramid framework, to be adapted to different geographical, socio-demographic, and cultural contexts in the different countries of the Mediterranean region.

Figure 3 illustrates the comparison between the FP developed in the present study and the recommended MDP (Serra-Majem *et al*., 2020). This figure shows that the designed FP consists of seven levels, involving from the bottom to the top: 1) water consumption; 2) cereals and starches; 3) sugars and sweeteners; 4) fruits and vegetables; 5) dairy products; 6) olive oil; and 7) pulses, nuts, red meat, fish, chicken, eggs, and olives. These seven levels are also found in the recommended MDP (Serra-Majem *et al*., 2020), but the order of the food groups' components is different. Indeed, in the recommended MDP, this order from the bottom to the top includes 1) sugar-free water and beverages in sufficient quantities; 2) fruits, vegetables, olive oil, cereal products and starches; 3) olives, nuts, seeds, plants, spices, garlic, onion, and legumes; 4) dairy products; 5) chicken, fish, and eggs; 6)red meat and processed meats; and 7) sugars and sweets. In addition, in terms of food variety and diversity, the present study found that red meat, chicken, fish, and eggs are eaten at a rate of 1 to 3 portions per week. Similarly, in the recommendations of the updated MDP (Serra-Majem *et al*., 2020), animal protein sources should be consumed weekly, no less than 2 portions per week for red meat, 2 portions per week for chicken, 2 portions per week for fish, and 2 to 4 eggs per week. The consumption of fish and seafood is an integral part of the MD. It is recommended twice a week due to their high content in proteins of high biological value (HBV), omega-3 fatty acids (eicosapentaenoic acid and docosahexaenoic acid), as in the case of sardines, which have been linked to a lower risk of coronary heart disease, and anti-inflammatory properties (Serra-Majem *et al*., 2020; Swanson *et al*., 2012).

Poultry and eggs are also an integral part of MD because of their high HVB protein content. Poultry is not rich in saturated fat like red meat, which has always been associated with certain chronic diseases (Abete *et al*., 2014). Other food groups have a different number of portions consumed by the study population than the MDP. These are olives consumed at a rate of 1 to 3 portions per week, whereas 2 portions per day is recommended (Serra-Majem *et al*., 2020); and dried fruits such as almonds and nuts consumed at a rate of 1 to 3 portions per week, whereas 1 to 2 portions per day is recommended (Serra-Majem *et al*., 2020).

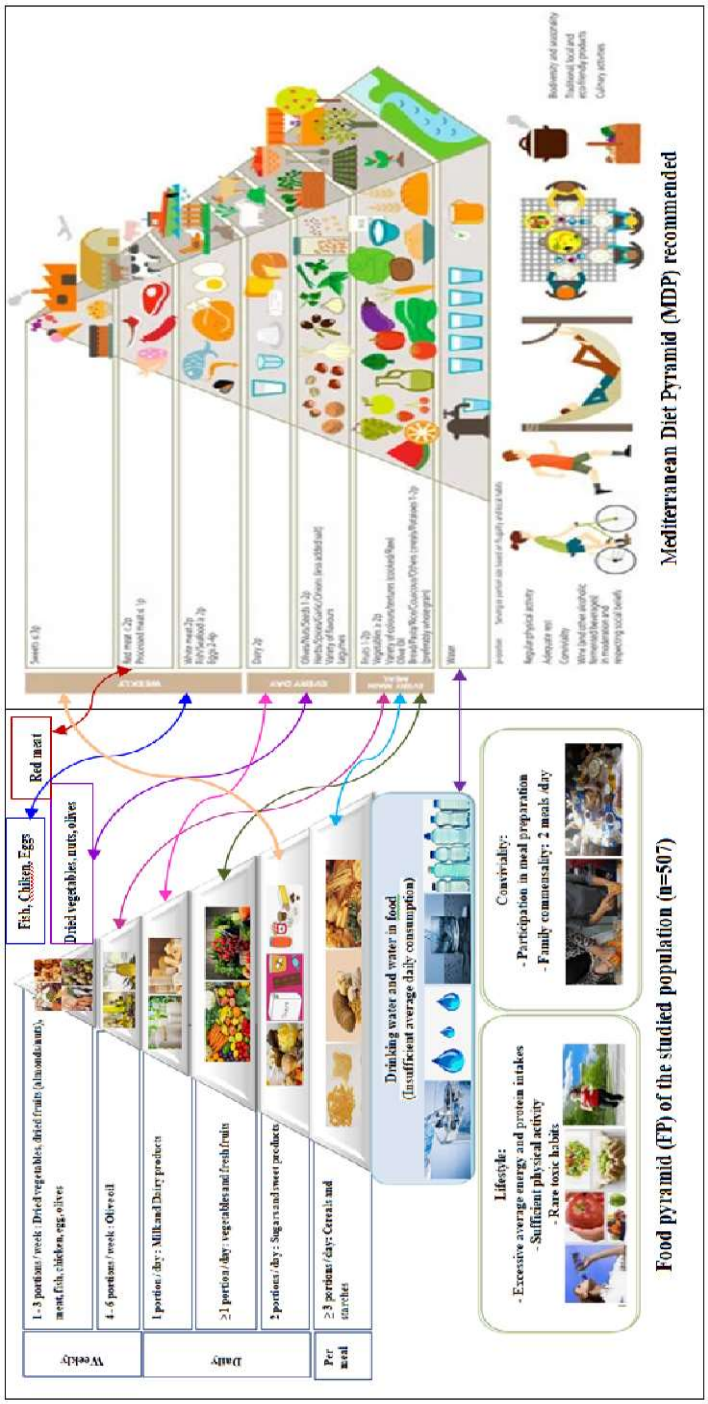

Figure 3. Comparison between FP of studied population and MDP recommended by Serra-Majem *et al*. (2020).

The recommendation to consume olives and nuts on a daily basis is associated with their nutritional and functional value, as they contain unsaturated fatty acids, minerals, vitamins, and fiber, as well as compounds with antioxidant potential, which contribute to overall well-being (De Souza *et al*., 2017). On the other hand, nuts have an important role in the primary prevention of cardiovascular disease (Estruch *et al*., 2018). The data obtained in this study also revealed a consumption of olive oil at a rate of 4 to 6 portions per week. This amount is low compared to the recommendations to consume it at each main meal because of its richness in unsaturated fatty acids (Serra-Majem *et al*., 2020). The role of olive oil in the primary prevention of cardiovascular diseases (Estruch *et al*., 2018) and certain cancers (Bosetti *et al*., 2009) has already been demonstrated. Although these foods are produced locally, this lower consumption can be explained by their high cost for the local population. In this study, the dairy group is consumed at one portion per day, thus fitting into the MDP recommendations that are 1 to 2 portions per day (Serra-Majem *et al*., 2020). Dairy products are good for the skeleton and muscles because they contain HVB proteins, calcium, and micronutrients, and they are also good for the digestive tract because they contain probiotics (Rozenberg *et al*., 2016; Fernandez and Marette, 2017).

The group of vegetables and fruits is revealed to be consumed with a portion of vegetables and a portion of fresh fruit per day. This amount is relatively lower than the recommendations of two portions per day of vegetables and 1-2 portions per day of fresh fruit (Serra-Majem *et al*., 2020). Fruits and vegetables are known to be sources of vitamins, minerals, dietary fibers, and antioxidants with beneficial health effects (FAO, 2003; OMS, 2018). Since this food group is produced locally and available to the population, this consumption below the recommendations could be associated with lifestyle changes, including those of the diet (Benjelloun, 2011; Ministère de la Santé (Maroc), 2018).

Furthermore, consumption of sugar and sweet products should be occasional (Serra-Majem *et al*., 2020), and is taken at the rate of two portions per day in the study population exceeding the recommendations. The negative effects of sugar and sweet products are responsible for the increase in energy intake associated with a sedentary lifestyle, which is involved in the occurrence of overweight, obesity and related chronic diseases (FAO, 2003). The cereals and starches food group is consumed in the present population at a frequency of at least three portions per day, which exceeds the recommendations of one to two portions per day with a preference for whole grains (Serra-Majem *et al*., 2020). Cereals and starches are slow-absorbing carbohydrates, which are, of course, preferable to simple sugars (OMS, 2018). However, the consumption of whole grains is preferable by obviously controlling the daily quantities or the consumed portion size (FAO, 2003; Johnson and Wallace, 2019).

In the light of these results, it appears generally that promoting the consumption of nuts, unrefined cereals, fish and seafood, pulses, fruits and vegetables is necessary. On the other hand, dairy products should be restricted and the consumption of soft drinks and foods, salty snacks, cold cuts, prepared dishes, pastries, and animal fats

should be prohibited (Maillot *et al*., 2011). In addition, portion sizes should be based on frugality and moderation, taking into account the energy needs for individual's lifestyle (Serra-Majem *et al*., 2020).

Lifestyle and friendliness are positioned at the bottom of the FP representation designed in the framework of this work. The study population was in the majority, sufficiently active and without any toxic habits. Nevertheless, it is characterized by excessive energy and protein and low dietary fiber and water intakes. The present data suggest that the surveyed population is at risk of being overweight (Branca *et al*., 2007) and may explain the high prevalence of overweight and obesity reported in the country (FAO, 2003). To guarantee the MD benefits, the adoption of a healthy lifestyle and the preservation of the traditional diet are necessary (Bach-Faig *et al*., 2011; UNESCO, 2010). Thus it is needed to avoid the risk factors related to poor eating habits and sedentary lifestyles, in addition to controlling energy, fat and sugar intake and regular physical or sports activity (HAS, 2011). One aspect of the Mediterranean model, which is still respected by the majority of the present study's respondents, is conviviality. Family commensality has been associated with healthier eating habits than food individualism (Barba-Orellana *et al*., 2020). In the present study, the respondents always take part in the preparation of meals in the household and had at least two meals daily with the family, which could have a positive impact on the health of this population. On the other hand, eating meals in groups could affect the size of the food portions eaten by each guest and is likely to not take into consideration the food preferences of each (Bricas, 1998). Nevertheless, culinary activities and shared meals are opportunities for the trans-generational transmission of culinary knowledge and recipes in a pleasant atmosphere (Serra-Majem *et al*., 2020).

Conclusions

In this work, the representation of the diet was built on the basis of the current food consumption specific to the population studied. In addition to allowing the comparison of data collected to the dietary recommendations, the design of a food pyramid specific to this population also facilitated its comparison with the published Mediterranean pyramid. It also demonstrated that the diet of the adult Moroccan population of Rabat-Salé-Kenitra is still of Mediterranean type, judging by the diversity and variety of foods, as well as the lifestyles and habits of conviviality. Nevertheless, the study also reveals differences in the number of food servings compared to the published MDP recommendation, showing a shift in adherence to this diet by the study population, linked, among others, to economic and life style factors. The designed dietary pyramid could serve also as an educational support for the nutritional education of this population.

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