The impact of optimized diet patterns at a macro-level: the case of Tunisia

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Summary

In the last 40 years Tunisia has experienced – as many other developing and emerging countries – a dietary transition, which led to an increase in the consumption of sugar, fats and animal products. This transition was accompanied by an increase in non-communicable diseases and particularly in cardio-vascular diseases. Using the framework developed by Srinivasan (2007) we optimized the Tunisian food intake using the French dietary recommendations (ANC) as constraints. We reproduced and enriched the work by including micronutrients in the analysis. Moreover we added a constraint on olive oil (a traditional culinary product in Tunisia), which consumption has also declined steadily over the period. Using this static model, we showed that the main needs in macro- and micronutrients are already covered by the food supply in Tunisia. However, the energy intake equivalent to 3329 Kcal per capita and per day, represented an average excess of 1000 Kcal for an adult. The adherence to all the dietary nutritional recommendations would induce an imperative shift to a less consumption of sugar and cereal-based products. Moreover, optimizing sustainable diets induced the reduction of the imports of cereals, sugar, and plant oils other than olive oil that is recognized to protect against cardiovascular diseases.

Keywords: dietary adjustment, food, olive oil, mathematical programming

JEL Classification codes: C61, I18

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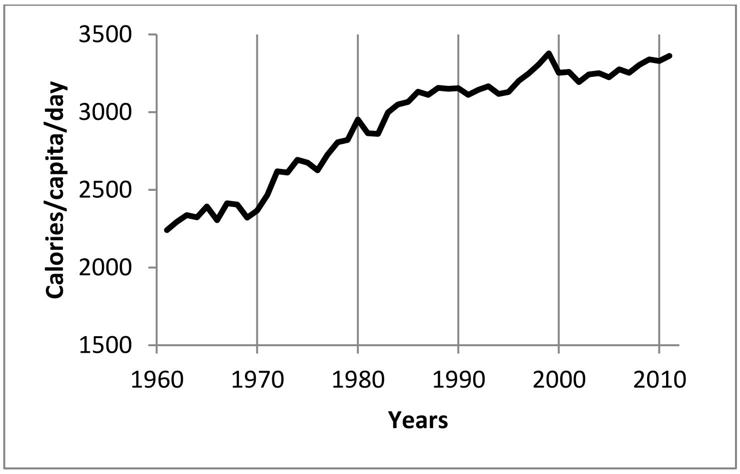
1. INTRODUCTION

Until the 70th, Tunisia faced a high poverty level and undernutrition problems. To tackle these issues, the Tunisian government has implemented social policies during these decades. Policies had the threefold objective of: improving food security, health and schooling of the Tunisian population. The food security aspect of the policy was based on direct and indirect food subventions. In the direct system, families received cash transfers under conditions among which, the number of children in the scholar system. The indirect part of the subvention system is a subsidy on the prices of staple food products (wheat, milk, oil seeds, sugar and tomato paste) and a non-edible product: scholar paper. The other side of the public policies implemented in these decades was focused on the improvement of the health system access (Dehibi and Gil, 2003).

The food subvention system it supposed to be progressive but inequality persists with poor population benefiting from fewer subventions in reality than in the theoretical system. Moreover poverty is still present and estimated at 15.5% of the population in 2010 (Ben Said *et al.*, 2011; Banque Africaine de Developpement, 2013b). However, these policies have been very effective in increasing the food calories intake, which increased steadily and reached in 2010 (according to the FAO Food Balance) an average of 3,329 calories per capita and per day (see figure 1).

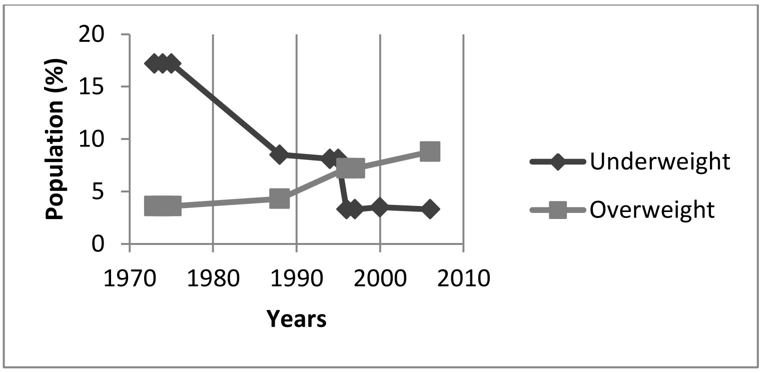
Figure 1. Caloric intake evolution



Source: Data from FAOSTAT

Over the period, Tunisia has experienced a decrease in the percentage of underweighted people and a concomitant increase of overweight. In 30 years the percentage of people suffering from underweight was divided by five. As shown in Figure 2, the two curves expressed in % of underweight and obese population crossed in the middle of the 1990s.

Figure 2. Underweight and overweight in percentage of the population (Tunisia, 1970-2010)

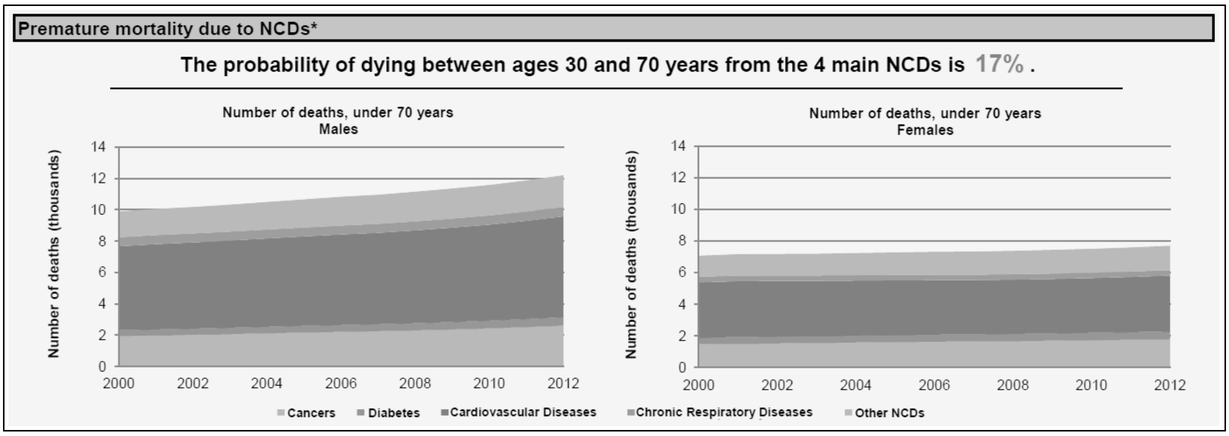


Source: data from the World Health Organization

This transition was accompanied with a change in food consumption and trade. As a main example the traditional olive oil consumption has been replaced by imported plant oils as maize, palm and soybean oils. Nowadays, almost all the olive oil produced in Tunisia is sold abroad mainly on the European Union markets (Anania and Pupo d'Andrea, 2007). Tunisia is also a net importer of cereals to be processed for human consumption or to feed animals. Finally, sugar has known the most important evolution. Imports of sugar were multiplied by more than four in 40 years. These changings in the traditional dietary patterns of the Tunisians have been largely influenced by the food subsidy system which encourages the consumption of wheat flour, vegetable, oils other than olive oil and sugar, products largely imported from abroad. This evolution is understandable as Tunisian authorities' main goal was to support the consumption of cheap high caloric-density food to fight against undernourishment. But as the objective has been almost reached (less than 5% of the population suffer from underweight in 2006), Tunisia is experiencing the inverse situation. The percentage of overweighed people increased from 3.5% in the 1970 to nearly 9% of the population in 2006. This food transition towards the consumption of more animal products, more fats and sugar leads to the emergence of diseases as diabetes and obesity linked to a non-balanced diet.

Figure 3 stresses the evolution of non-communicable diseases (NCD) in Tunisia. As this figure shows, the number of deaths before the age of 70 from NCD and particularly from cardiovascular diseases has evolved positively over the period (particularly for men).

Figure 3. Premature mortality due to NCD



Source: World Health Organization – Non communicable Diseases (NCD) Country Profiles, 2014.

Even if food transition in Tunisia (as in many developing countries) seemed unavoidable (Rayner *et al.*, 2007), the food subsidy system has certainly significantly amplified the dietary transition (Lobstein, 2002). This situation is all the more worrying that Tunisia has become net importer of cereals, meat, sugar, milk and plant oils (others than olive oil), i.e. the products, which are the main culprit of this transition.

The objective of our study was to assess the impact of optimizing the Tunisian dietary pattern at a macro-level. Using the mathematical programming model described in Srinivasan (2007) we optimized the Tunisian food intake based on the French nutrition recommendations hereafter, ANC (Martin, 2001; see table 3 in Appendix). We evaluated the impact on the Tunisian consumption, production and trade of the adherence to the ANC. The paper is organized as followed section 2 presents the sources and the matching of data, section 3 describes the model. Results are discussed in section 4 and section 5 concludes.

2. THE DATA

In order to perform this analysis we had to reconcile three sources of data. The food balance sheets (FBS) from the FAO, which give data estimates of production, utilization and trade for 111[1] food items (FAO, 2011) and two databases of food contents of macro- and micronutrients: the French databases Ciqual (Ciqual, 2012) and Nutrinet (Nutrinet-Sante, 2013). They are composed of respectively 1,343 and 2,609 food products and 60 macro and micronutrients and other food compounds.

In order to reconcile the FBS and the nutrition datasets, a matching was necessary between the definitions of the products in the three bases. In priority the Ciqual product description was considered. Where a product was not available in Ciqual, the Nutrinet database was considered. When a food item was not available in both nutritional databases, we used average foods, which categorize family of products or the closest product we could associate based on the comparison of nutrients compounds. For instance, the nutrient composition of pulses was elaborated by the ponderation of products from this food category according to the Tunisian consumption of these products.

To show the deviation between the observed quantity of nutrients intake in Tunisia in 2010 and the ANC, we computed (as in Hatluy *et al.*, 1998) the Nutrient Adequacy Ratio (NAR)

[1] We analyze only 62 items after selection of influent products on Tunisian trade.

$$NAR_j = \frac{N_j}{N_j'}$$

Where N_j represents the observed intake of nutrient j and N_j' is the ANC recommended intake of the same nutrient. When NAR_j is equal to 1 the need is covered; when it is greater than 1 the need is covered but the nutrient exceeds the upper limit; when it is lower than 1 the need is not covered. The same calculation is made with the optimized diet to evaluate the adequacy of the model results to the nutritional recommendations.

The FAO food balance sheets for Tunisia in 2010 have been used to estimate individual food intake. Table 4 in Appendix shows the observed food utilization by food items in 2010 in Tunisia per capita per day in grams. It does not represent the exact food consumption in Tunisia but a broad picture of the quantity of agrofood product available for food consumption. Del Gobbo *et al.* (2015) have shown that these "guestimates" from the FAO are largely over or under estimated; the estimation error can attain (according to country) +270% for whole grain and -50% for beans and legumes. For this reason we did not use the quantities as the actual consumption of food. We kept the proportion of each item for a theoretical daily intake of 2,000 calories (Table 5 in Appendix). This restriction to 2,000 calories is not undertaken via the model but is a simple beforehand proportional computation.

3. THE MODEL

We used the non-linear programming approach described in Srinivasan (2007). The simulations are made using the GAMS software. The model is composed of 62 foods items detailed in table 4 in Appendix which represent the Tunisian diet observed in 2010. Or more accurately it shows the food utilization of 62 items equivalents.

We minimized the following objective function (*Z*), which is the sum of the square of the differences between the observed theoretical consumption X_i and the optimized consumption X_i' for each item *i* times a coefficient α_i which is the calorific share of each item in the total observed calorific content (restraint to 2,000 calories) computed from E_i the calorific content per gram of each item i.

$$Z = \sum_i \alpha_i \left(\frac{X_i' - X_i}{X_i} \right)$$

$$\alpha_i = \frac{E_i X_i}{\sum_i E_i X_i}$$

Z is minimized under a set of constraints, which corresponds to the ANC recommendations summarized in table 3 in Appendix. These recommendations focus on 34 macro- and micronutrients. We eliminated sodium and iodine from the simulations. Indeed, the added salt is not taken into account in the FBS. However, in Tunisia as in many other countries, the consumption of added salt is so high that it becomes a public health problem, according to Mason *et al.* (2014), the average daily salt intake in Tunisia is 14 g. We thus guess that the need of sodium is largely covered and as the salt is enriched with iodine, we also guess that this constraint is also satisfied. The men/women median is considered as the minimum of nutrient constraint. The maximum limit (when they exist) sets the safety limit for some nutrients.

Two additional constraints were taken into account: (i) a total intake of fruit and vegetables greater than 200 grams for each group is imposed. It allows a total daily intake of fruit and vegetables of more than 400 grams as recommended by health policies in different countries.

$$\sum_{fruits\&veg} X_{fruits\&veg} \geq 400$$

(ii) a quantity of olive oil. Since the 70th, Tunisians have gradually replace olive oil by other plant oil largely subsidized by the government. Olive oil was the main plant oil consumed before the implementation of the food subsidy system and its consumption became less in the Tunisian diet. Nowadays other plant oils represent a high proportion of the Tunisian oil consumption. Though, olive oil is one of the main components of the Mediterranean diet and was shown to contribute to the protection of cardiovascular diseases. This particularity is supposed to be linked to the phenolic molecules present in olive oil (Amiot, 2014). Buckland *et al.* (2012) have shown that each increase of 10 grams of olive oil intake is associated to a risk decrease of cardio-vascular mortality by 13% and the risk of coronary heart disease mortality by 7%. Tunisian olive oil consumption in 2010 is estimated at 8.2 grams per day (g/d) while it was estimated at 26 g/d in 1970 (FAOSTAT). Concomitantly, according to the WHO, in 2006 29.1% of deaths in Tunisia were linked to cardiovascular diseases (WHO, 2010). Then we added in the model a constraint on olive oil requiring that the optimized diet includes (at the minimum) the observed olive oil intake plus 10 grams.

$$X'_{olive\ oil} = X_{olive\ oil} + 10$$

4. RESULTS

Table 1 displays the values of NAR_j for each macro- and micronutrient listed in the French ANC. The actual Tunisian diet (at 3,600 kcal) is well above the French dietary recommendations for all the nutrients except calcium and vitamin D (in a lower extent). This diet is also too rich in sugar, carbohydrates and fats.

Once the optimization done, all the nutrients respect the upper and lower limits; they are under 1 when we consider the upper limits and above 1 considering the lower limits. Fats, carbohydrates and free sugar have adequately evolved. Finally, except for those three compounds, the Tunisian diet is enough diversified and does not show (on average) serious deficit.

Table 1. Observed and optimized Nutrient Adequacy Ratio

Nutrients	NAR_j for 3,600 kcal	NAR_j after optimization
Proteins	2.43 – 1.21	1.98 – 0.99
Total fats	1.93 – 1.11	1.29 – 0.74
Carbohydrates	2.35 – 1.57	1.18 – 0.79
Cholesterol	0.60	0.58
Monounsaturated fatty acids	0.89 – 0.67	0.47 – 0.35
Linoleic acid	4.70 – 1.31	2.07 – 0.58
Linolenic acid	5.94	2.74
EPA + DHA	1.69	1.89
Omega 3	6.32 – 1.58	3.17 – 0.79
Polyunsaturated fat acids	2.22 – 1.21	1 – 0.55
Saturated fatty acids	0.86 – 0.39	0.59 – 0.27
Free sugar	1.90 - 0.38	0.23 – 0.05
Fibres	0.87	1.18
Vitamin A	1.75 – 0.68	2.54 – 0.99
Vitamin B1	1.21	1.22
Vitamin B2	1.09	1.15
Vitamin B3	2.83 – 0.75	2.2 – 0.58
Vitamin B5	1.50	1.31
Vitamin B6	1.36 – 0.33	1.31 – 0.32
Vitamin B9	1.52 – 0.32	1.8 – 0.38
Vitamin B12	1.29	1.57
Vitamin C	1.29 – 0.13	1.56 – 0.15
Vitamin E	1.78 – 0.41	1.46 – 0.34
Vitamin D	0.91 – 0.09	1 – 0.1
Calcium	0.85	1
Phosphorus	2.00	1.81
Potassium	1.42	1.51
Iron	1.39	1.45
Magnesium	1.08	1.09
Zinc	1.05 – 0.23	1 – 0.22
Copper	1.08	1
Selenium	1.96 – 0.31	1.63 – 0.26
Fruit and Vegetables	2.34	3.18
Calories	1.84	1.05

Table 2 displays the impact of the adherence to the French dietary recommendations for Tunisia. The simulation is done without considering age and gender but for an already optimum of 2,000 kcal per day and per person. First, decreasing the daily caloric intake from 3,684 to 2,000 kcal is a uniform decrease by 45% of each item. Then, we performed our simulation. The model simulates the optimized diet from the actual proportion of each item in the total consumption. Hereafter, percentage variations are computed with respect to the actual consumption of 3,600 kcal (see last column of table 2). Results are displayed in table 2 for some aggregates. Detailed results are provided in tables 6 and 7 in Appendix.

Table 2. Consumption in grams per day and per person in the baseline and after optimization and percentage variation.

	Actual consumption 3,600 kcal (in g/d/pers.)	Consumption at 2,000 kcal (in g/d/pers.)	Optimized cons. 2,000 kcal (in g/d/pers.)	Percentage variation between the actual and optimized diet (in %)
Cereals	581.92	315.96	240.66	-58.64
Coffee, cocoa tea and spices	17.26	9.37	23.99	38.99
Milk and cream	297.54	161.55	327.60	10.10
Fruit	244.10	132.54	200.00	-18.07
Legumes and potatoes	106.58	57.87	82.37	-22.72
Meats and eggs	99.73	54.15	112.27	12.57
Nuts	15.07	8.18	15.85	5.18
Oils and Fats	51.51	27.97	22.85	-55.65
Fish and seafood	35.34	19.19	38.08	7.74
Sugar	95.89	52.06	11.58	-87.92
Vegetables	694.24	376.94	1073.03	54.56

In order to optimize his (her) diet an average Tunisian should decrease drastically his (her) share of sugar (-88%) in his (her) overall consumption. This item is the more problematic nutrient in the Tunisian dietary pattern. Sugar is largely supported by the food subvention system and it is totally imported from abroad. However, the consumption of sugar should not exceed 50% to 75% of the total energy on average according to the French ANC. But the 2010 nutritional balance displays figures well above these recommendations. The ratio for carbohydrates ranged between 2.35 and 1.57 and between 1.90 and 0.38 for free sugar, i.e. two times the recommended level.

The second item to reduce is oils and fats (-55%) even in a less extent than sugar. Fortunately, the oils consumed in Tunisia are mainly from plant origin. Concerning fats, as imposed by the olive oil constraint, the consumption of all oils and fats must be reduced except olive oil which has to be increased by 75% in this simulation to reach the threshold of “plus 10 grams” a day.

Concerning fruit, which are among (along with vegetables) the main nutritionally dense food category, the Tunisians consumption seems already adequate as the results of the simulation show a general reduction (-18%) in the consumption of fruit (particularly dates certainly due to their high sugar content).

Conversely, the consumption of vegetables should be increased by 55% (+30% for tomatoes and +70% for other vegetables).

Considering cereals, their consumption should be decreased (-58%), particularly wheat, which is the main cereal consumed in Tunisia (-60%). Wheat has been also supported by the Tunisian food subsidy system and nowadays Tunisia is largely dependent on imports to assure the needs of cereals.

Concerning the consumption of legumes, it should be decreased by only 22% showing a rather good adaptation of the actual Tunisian diet of this item.

Finally, it seems that the transition towards a Western diet is not the main problem of Tunisians whose consumption of products from animal origin can be increased (+12% for meat and eggs; +10% for dairy products) and particularly the consumption of red meats (+60%).

We have used the results of the simulation to compute the impact in terms of macro-data and particularly in terms of trade. Indeed, we can guess that in the case of a severe modification in the Tunisian diet, the trade would be affected before the transformation of the productive structure. The scenario described here of a reduction from 3,600 to 2,000 kcal and the reallocation of food items towards less fats and sugar more olive oil and more vegetables would have the following consequences on net trade (see table 8). Tunisia would decrease drastically its imports of cereals and sugar (and its dependence from international markets). It would become a net exporter of potatoes and reduce somewhat its exports of olive oil.

5. Discussion and conclusions

In this analysis we used the mathematical programming model described in Srinivasan (2007) to represent and simulate a changing in the Tunisian diet pattern. Using data from the food balance sheets of the FAO for 2010 we computed a reduction of the average caloric intake from 3,600 to 2,000 kcal per person and per day keeping the share of each item constant. Then we optimized this diet to respect the adequacy with the French recommendations (ANC) on macro- and micronutrients. Two other constraints were added to this general framework: a constraint on a minimal consumption of fruit and vegetables and a constraint on olive oil.

1- A first analysis of the Tunisian diet computing the ratios of nutrient adequacies showed that thanks to the rather diversified agricultural production, Tunisians (on average) does not suffer from severe deficit in nutrients.

2- Results of the optimization showed that the consumption of fruit and vegetables is already satisfying and the consumption of meat is not problematic. Conversely the consumption of carbohydrates from cereals and fats (except olive oil) must be dramatically reduced.

As a consequence, the adherence to these recommendations has some impacts at the macro-level. The reduction in carbohydrates intake would induce a decrease in wheat-based products consumption, which would entail a decrease of 1,304 thousand tons of wheat (and wheat equivalent) imports and a decrease of potatoes consumption translating in an increase of 110,000 tons of potatoes' exports.

The imports of sugar would also be dramatically reduced with a decrease of imports of 315,000 tons.

The reduction in fats and oils (except olive oil) would reflect at the macro-level the stop of soybean oil imports and a moderate reduction of olive oil exports. The olive oil constraint may represent a loss in terms of foreign inflows for Tunisia. But this additional 10 grams, as stressed before, could represent a reduction in the number of cardiovascular deaths each year.

In order to maintain a safe level of iron and proteins, the results of the modeling exercise does not recommend decreasing the consumption of products from animal origin. The consumption of red meat is particularly encouraged leading to an increase in the net imports of beef and mutton meat.

Concerning fruit and vegetables; tomatoes and other vegetables should be more consumed. It implies an increase in the importations of these products in the short term and a dimensioning of their production. According to the optimization, imports of these products would increase by 300 and 900,000 tons.

Finally, in line with the reduction of carbohydrates Tunisian consumers should reduce their fruit intake. This can be made without dramatic change in trade except for dates and some citrus.

Such modeling is useful to re-orientate the current public policies in Tunisia. Tunisian public policies for food security have been very efficient in cutting down under-nourishment. However Tunisia is nowadays confronted to the triple burden linked to the coexistence of undernourishment (reduced to 5% but still remaining), nutrient deficiencies and obesity. A gap still remains between of rich and poor's caloric intake; respectively 2594 kcal/capita/day and 1903 kcal/capita/day (Banque Africaine de Developpement, 2013a).

Nutritional transition was largely influenced by the food subsidy system. Food security was insured by Tunisian social policies based on direct subventions to families and indirect ones by lowering the prices of essential food products (wheat, milk, seed oils, sugar and tomato paste). As stressed by Lobstein (2002) food policies fail in delivering healthy diets. Our work proposes insights for redesigning public food policies. We took into account the actual dietary pattern of the Tunisian population at a macro-level and the capacity of production and the international trade to improve the food intakes. However, our work suffers from some limits that reduce the scope of the analysis. First, the food balances from FAO seem to be (according to countries) largely over or under-estimated. In Tunisia this over-estimation would reach 30%. The analysis does not take into account gender and age or socio-economic distribution in the computation. Yet, the nutritional needs will differ a lot according to the age or gender. Moreover, we did not include prices or budget constraint and then the ability of Tunisians to switch from one diet to another has to be analyzed.

APPENDIX

Table 3. French daily nutritional recommendations (ANC)

Nutrient	For 2000 kcal adult average	Safety limits
Protein (% total energy)	10 - 20	--
Total fats (% total energy)	20 - 35	--
Carbohydrates (% total energy)	50 - 75	--
Cholesterol (mg)	≤ 300	--
Monounsaturated fatty acids (% total energy)	15 - 20	--
Linoleic acid (% total energy)	≥ 0.5	--
Linoleic acid (% total energy)	2.5 - 9	--
EPA+DHA (g)	≥ 0.25	--
W3 (% total energy)	0.5 - 2	--
Polyunsaturated fat acids (% total energy)	6 - 11	--
Saturated fatty acids (% total energy)	10 - 22	--
Free Sugar (% total energy)	10 - 50	--
Sodium (mg)	1500 - 2759	--
Fibers (g)	≥ 30	--
Vitamin A (µg)	≥ 700	≤ 1800
Vitamin B1 (mg)	≥ 1.2	--
Vitamin B2 (mg)	≥ 1.55	--
Vitamin B3 (mg)	≥ 12.5	≤ 47
Vitamin B5 (mg)	≥ 5	--
Vitamin B6 (mg)	≥ 1.65	≤ 6.8
Vitamin B9 µg	≥ 315	≤ 1500
Vitamin B12 µg	≥ 2.4	--
Vitamin C (mg)	≥ 110	≤ 1110
Vitamin E (mg)	≥ 12	≤ 52
Vitamin D (µg)	≥ 3	≤ 30
Calcium (mg)	≥ 900	--
Phosphor (mg)	≥ 750	--
Potassium (mg)	≥ 3100	--
Iron (mg)	≥ 12.5	--
Magnesium (mg)	≥ 390	--
Zinc (mg)	≥ 11	≤ 50
Copper (mg)	≥ 1.75	--
Iodine (µg)	≥ 150	--
Selenium (µg)	≥ 55	≤ 350

Source: Martin A. (2001)

Table 4. Observed diet for 3684 kcal

Items	Daily consumed quantity (g)	Items	Daily consumed quantity (g)
Rice	2.47	Potatoes	82.47
Sugar	92.60	Sweeteners	2.19
Honey	1.10	Beans	1.64
Peas	3.84	Pulses	18.63
Nuts	13.70	Groundnuts	1.37
Soybean Oil	27.40	Sunflower seed Oil	2.74
Rapeseed Oil	1.37	Olive Oil	8.22
Maize Oil	1.64	Tomatoes	297.26
Onions	33.97	Vegetables	362.74
Oranges	35.62	Lemons	8.49
Grapefruit	19.73	Citrus	24.93
Bananas	4.38	Apples	28.77
Pineapples	0.27	Dates	15.34
Grapes	16.16	Fruit	90.41
Coffee	4.93	Cocoa	1.10
Tea	2.74	Spices	4.38
Wine	4.66	Beer	22.19
Beverages Fermented	0.27	Beverages Alcoholic	0.27
Bovine Meat	15.62	Mutton Meat	15.62
Poultry Meat	41.64	Meat	2.47
Offal	4.11	Butter	1.64
Cream	2.74	Fats	0.55
Eggs	20.27	Milk	294.80
Freshwater Fish	0.55	Demersal Fish	7.95
Pelagic Fish	25.21	Marine Fish	0.82
Crustaceans	0.27	Mollusks	0.27
Oil crops Oil	0.55	Coconut Oil	1.10
Sorghum	1.64	Barley	15.89
Palm Oil	6.30	Soybeans	4.11
Cephalopods	0.27	Pimento	0.27
Cereals	2.47	Wheat	559.45

Source: FAOSTAT Food Balance Sheets

Table 5. Observed diet for 2000 kcal

Items	Daily consumed quantity (g)	Items	Daily consumed quantity (g)
Rice	1.34	Potatoes	44.78
Sugar	50.28	Sweeteners	1.19
Honey	0.60	Beans	0.89
Peas	2.08	Pulses	10.12
Nuts	7.44	Groundnuts	0.74
SoyabeanOil	14.88	SunflowerseedOil	1.49
RapeOil	0.74	OliveOil	4.46
MaizeOil	0.89	Tomatoes	161.40
Onions	18.45	Vegetables	196.95
Oranges	19.34	Lemons	4.61
Grapefruit	10.71	Citrus	13.54
Bananas	2.38	Apples	15.62
Pineapples	0.15	Dates	8.33
Grapes	8.78	Fruit	49.09
Coffee	2.68	Cocoa	0.60
Tea	1.49	Spices	2.38
Wine	2.53	Beer	12.05
BeveragesFermented	0.15	BeveragesAlcoholic	0.15
BovineMeat	8.48	MuttonMeat	8.48
PoultryMeat	22.61	Meat	1.34
Offals	2.23	Butter	0.89
Cream	1.49	Fats	0.30
Eggs	11.01	Milk	160.06
FreshwaterFish	0.30	DemersalFish	4.31
PelagicFish	13.69	MarineFish	0.45
Crustaceans	0.15	Molluscs	0.15
CoconutOil	0.60	OilcropsOil	0.30
Barley	8.63	Sorghum	0.89
Soyabeans	2.23	PalmOil	3.42
Pimento	0.15	Cephalopods	0.15
Wheat	303.76	Cereals	1.34

Source: Authors own calculations based on FAOSTAT Food Balance Sheets

Table 6. Optimized diet without olive oil constraint

Items	% variation	Daily consumed quantity (g)	Items	% variation	Daily consumed quantity (g)
Rice	-51.01	1.11	Potatoes	-36.97	50.02
Sugar	-80.76	11.09	Sweeteners	-80.82	0.26
Honey	-72.73	0.23	Beans	46.34	2.49
Peas	34.11	5.31	Pulses	27.64	24.55
Nuts	10.36	15.44	Groundnuts	-66.42	0.41
SoyabeanOil	-74.09	5.91	SunflowerseedOil	-74.82	0.57
RapeOil	-78.10	0.22	OliveOil	-80.41	14.46
MaizeOil	-75.61	0.33	Tomatoes	34.47	413.57
Onions	3.94	35.3	Vegetables	66.59	623.97
Oranges	-10.56	31.88	Lemons	5.65	9.36
Grapefruit	-7.10	18.62	Citrus	-10.55	22.32
Bananas	-27.85	3.12	Apples	-32.50	19.13
Pineapples	55.56	0.44	Dates	-45.70	7.8
Grapes	-12.69	14.19	Fruit	-19.17	73.14
Coffee	8.72	5.36	Cocoa	24.55	1.4
Tea	8.76	2.98	Spices	97.03	8.95
Wine	-34.55	3.05	Beer	17.94	27.38
BeveragesFermented	18.52	0.34	BeveragesAlcoholic	18.52	0.34
BovineMeat	55.51	25.3	MuttonMeat	55.51	25.3
PoultryMeat	-20.68	34.01	Meat	55.47	3.99
Offals	55.47	6.66	Butter	-78.05	0.25
Cream	-71.17	0.61	Fats	-78.18	0.08
Eggs	-14.60	17.02	Milk	14.01	326.99
FreshwaterFish	-34.55	0.35	DemersalFish	-34.47	5.04
PelagicFish	21.70	30.69	MarineFish	-39.02	0.5
Crustaceans	85.19	0.5	Molluscs	85.19	0.5
CoconutOil	-79.09	0.16	OilcropsOil	-78.18	0.08
Barley	-14.03	13.47	Sorghum	12.20	1.87
Soyabeans	24.33	5.31	PalmOil	-80.48	0.8
Pimento	-29.63	0.19	Cephalopods	85.19	0.5
Wheat	-55.87	223.24	Cereals	-55.87	0.98

Table 7. Optimized diet with olive oil constraint

Items	% variation	Opt. consumption (g/d)	Items	% variation	Opt. consumption (g/d)
Rice	-55.06	1.11	Potatoes	-39.35	50.02
Sugar	-88.02	11.09	Sweeteners	-88.13	0.26
Honey	-79.09	0.23	Beans	51.83	2.49
Peas	38.28	5.31	Pulses	31.78	24.55
Nuts	12.70	15.44	Groundnuts	-70.07	0.41
SoyabeanOil	-78.43	5.91	SunflowerseedOil	-79.20	0.57
RapeOil	-83.94	0.22	OliveOil	75.91	14.46
MaizeOil	-79.88	0.33	Tomatoes	39.13	413.57
Onions	3.92	35.3	Vegetables	72.02	623.97
Oranges	-10.50	31.88	Lemons	10.25	9.36
Grapefruit	-5.63	18.62	Citrus	-10.47	22.32
Bananas	-28.77	3.12	Apples	-33.51	19.13
Pineapples	62.96	0.44	Dates	-49.15	7.8
Grapes	-12.19	14.19	Fruit	-19.10	73.14
Coffee	8.72	5.36	Cocoa	27.27	1.4
Tea	8.76	2.98	Spices	104.34	8.95
Wine	-34.55	3.05	Beer	23.39	27.38
BeveragesFermented	25.93	0.34	BeveragesAlcoholic	25.93	0.34
BovineMeat	61.97	25.3	MuttonMeat	61.97	25.3
PoultryMeat	-18.32	34.01	Meat	61.54	3.99
Offals	62.04	6.66	Butter	-84.76	0.25
Cream	-77.74	0.61	Fats	-85.45	0.08
Eggs	-16.03	17.02	Milk	10.92	326.99
FreshwaterFish	-36.36	0.35	DemersalFish	-36.60	5.04
PelagicFish	21.74	30.69	MarineFish	-39.02	0.5
Crustaceans	85.19	0.5	Molluscs	85.19	0.5
CoconutOil	-85.45	0.16	OilcropsOil	-85.45	0.08
Barley	-15.23	13.47	Sorghum	14.02	1.87
Soyabeans	29.20	5.31	PalmOil	-87.30	0.8
Pimento	-29.63	0.19	Cephalopods	85.19	0.5
Wheat	-60.10	223.24	Cereals	-60.32	0.98

Table 8. Production, trade and consumption by food item

	Domestic Supply (1000 tons)					Observed food utilization			Optimized
Items	Production	Importation	Exportation	Net trade (Exp.-Imp.)	Optimized net trade (Exp.-Imp.)	3684 kcal	2000 kcal	Difference between 3684 and 2000	Food optimized
Wheat and products	822	1920	155	-1765	-460.32	2171	1178.80	-992.2	866.32
Rice (Milled Equivalent)		10	0	-10	-4.31	10	5.20	-4.80	4.31
Barley and products	237	445	0	-445	-435.27	62	33.49	-28.51	52.27
Maize and products		900	0	-900	-899.00		0.00	-0	0.00
Sorghum and products	1	6	0	-6	-7.26	6	3.45	-2.55	7.26
Cereals, Other	48	1	0	-1	4.20	10	5.20	-4.8	3.80
Potatoes and products	370	25	10	-15	111.89	320	173.78	146.22	194.11
Sugar (Raw Equivalent)	0	352	10	-342	-26.04	359	195.12	163.88	43.04
Sweeteners, Other	4	12	7	-5	2.99	9	4.62	4.38	1.01
Honey	4	0	0	0	3.11	4	2.33	1.67	0.89
Beans	0	7	0	-7	-9.66	6	3.45	2.55	9.66
Peas	13	2	0	-2	-7.61	15	8.07	6.93	20.61
Pulses, Other and products	78	21	1	-20	-42.27	73	39.27	33.73	95.27
Nuts and products	54	9	5	-4	-10.92	53	28.87	24.13	59.92
Soybeans		422	0	-422	-426.61	16	8.65	7.35	20.61
Groundnuts (Shelled Eq)		5	0	-5	-1.59	5	2.87	2.13	1.59
Soybean Oil	68	158	77	-81	2.07	106	57.74	48.26	22.93
Sunflower seed Oil	2	10	1	-9	-0.21	11	5.78	5.22	2.21
Rape and Mustard Oil		0		0	4.15	5	2.87	2.13	0.85
Palm Oil		60	4	-56	-35.10	24	13.27	10.73	3.10
Coconut Oil		4	0	-4	-0.62	4	2.33	1.67	0.62
Olive Oil	196	1	117	116	92.89	32	17.31	14.69	56.11
Maize Germ Oil		58	28	-30	-25.28	6	3.45	2.55	1.28
Oil crops Oil, Other	2	6	10	4	6.00	2	0.00	2	0.00

Tomatoes and products	1296	29	101	72	-379.93	1153	626.34	526.66	1604.93
Onions	147			0	-4.99	132	71.60	60.4	136.99
Vegetables, Other	1667	16	56	40	-973.43	1407	764.30	642.7	2421.43
Oranges, Tangerines	174	10	28	18	33.28	138	75.05	62.95	123.72
Lemons, Limes and products	37	1	2	1	-3.32	33	17.89	15.11	36.32
Grapefruit and products	87	0	0	0	4.74	77	41.56	35.44	72.26
Citrus, Other	104	0	0	0	10.38	97	52.54	44.46	86.62
Bananas		19	0	-19	-13.11	17	9.24	7.76	12.11
Apples and products	126	3	0	-3	34.76	112	60.62	51.38	74.24
Pineapples and products		1	0	-1	-1.71	1	0.58	0.42	1.71
Dates	174	1	85	84	112.73	59	32.33	26.67	30.27
Grapes and products (excl wine)	97	4	1	-3	3.93	63	34.07	28.93	55.07
Fruit, Other	423	4	32	28	95.17	351	190.50	160.5	283.83
Coffee and products		19	0	-19	-20.80	19	10.40	8.6	20.80
Cocoa Beans and products		8	4	-4	-5.43	4	2.33	1.67	5.43
Tea (including mate)		10	0	-10	-11.56	10	5.78	4.22	11.56
Pimento	12	2	13	11	10.26	1	0.58	0.42	0.74
Spices, Other	13	6	1	-5	-22.73	17	9.24	7.76	34.73
Wine	22	0	3	3	9.16	18	9.82	8.18	11.84
Beer	92	0	2	2	-18.25	86	46.76	39.24	106.25
Beverages, Fermented	2	0	2	2	0.68	1	0.58	0.42	1.32
Beverages, Alcoholic	1	1	1	0	-0.32	1	0.58	0.42	1.32
Bovine Meat	56	4	0	-4	-42.18	60	32.91	27.09	98.18
Mutton & Goat Meat	59	1	0	-1	-40.18	60	32.91	27.09	98.18
Poultry Meat	161	3	3	0	29.02	161	87.74	73.26	131.98
Meat, Other	10	0	1	1	-5.48	9	5.20	3.8	15.48
Offal, Edible	15	0	0	0	-10.85	15	8.65	6.35	25.85
Butter, Ghee	6	0	0	0	5.03	6	3.45	2.55	0.97

Cream	20	0	10	10	17.63	10	5.78	4.22	2.37
Fats, Animals, Raw	6	1	6	5	6.69	2	1.16	0.84	0.31
Eggs	92	2	0	-2	10.95	79	42.73	36.27	66.05
Milk - Excluding Butter	1069	142	7	-135	-259.94	1144	621.14	522.86	1268.94
Freshwater Fish	2	0	0	0	0.64	2	1.16	0.84	1.36
Demersal Fish	29	4	2	-2	9.44	31	16.73	14.27	19.56
Pelagic Fish	58	53	12	-41	-61.10	98	53.13	44.87	119.10
Marine Fish, Other	3			0	1.06	3	1.75	1.25	1.94
Crustaceans	3	1	3	2	1.06	1	0.58	0.42	1.94
Cephalopods	7	1	6	5	5.06	1	0.58	0.42	1.94
Mollusks, Other	1	1	0	-1	-0.94	1	0.58	0.42	1.94

Source: Authors own calculations based on Food balance sheet from FAOSTAT (2010)

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