Optimised Diet and Imports Dependence in Tunisia

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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. Tunisian policies had the three objectives to improve (i) food security, (ii) health and (iii) schooling. Policy on food security 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 price subsidy on staple food products (wheat, milk, oil seeds, sugar and tomato paste) and scholar paper. Moreover, public policies implemented in these decades were focused on the improvement of the health system access (Dhehibi and Gil, 2003).

These policies have been very effective in increasing the food calories availabilities, which increased steadily and reached in 2010 an average of 3,329 calories per capita and per day (according to the FAO apparent consumption see figure 1). The food subvention system was supposed to be progressive but inequality persists with poor population benefiting from fewer subventions in reality than in the theory. Poverty is still present and estimated at 15.5% of the population in 2010 (Ben Said *et al.*, 2011; Banque Africaine de Developpement, 2013b). Consequently, a gap remains between of rich and poor's caloric intake; respectively 2,594 kcal/capita/day and 1,903 kcal/capita/day (Banque Africaine de Developpement, 2013a).

[INSERT Figure 1]

However, this dietary trend has benefited more to high energy than nutritionally dense products, influenced by the food subsidy system, which has encouraged the consumption of affordable products largely imported from abroad: wheat flour, vegetable oils other than olive oil and sugar. 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 vegetable oils (others than olive oil), i.e. the products, which are the main culprit of this transition (see table A5 in Appendix; Le Mouël and Schmitt, 2018). Observed transitions were accompanied with changes in both food consumption and trade. As a main example, the traditional olive oil consumption has been replaced by imported vegetable 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 animal feed. Finally, sugar displayed the most important evolution. Imports of sugar (in raw sugar equivalent) were multiplied by more than four in 40 years (FAOSTAT Food Balance Sheets, hereafter FBS).

These changings towards more westernized diets are understandable as Tunisian authorities aimed at supporting the consumption of cheap high caloric-density food to fight against undernourishment. In 30 years the percentage of people suffering from underweight was divided by five and reached less than 5% of the population (adults and children less than 5) from 1999 onwards. The situation evolves in such a way that the prevalence of undernourishment in total population was equal to 5% in 2015-2017 according to the FAO report on nutrition and food security situation (FAO *et al.*, 2018). But concomitantly, overweight increased and the prevalence of of overweighed people evolved from 10% in 1975 to nearly 30% of the population in 2016. As shown in figure 2, the two curves expressed in % of underweight and obese population crossed in the early 1980s. In addition, the prevalence of overweighed children aged less than 5 was 14% in 2012 (FAO *et al.*, 2018). The problem of overweight and obesity in Tunisia as a consequence of unbalanced diets and nutritional transition towards consuming more animal products, fat and sugar and a loss of tradition Medieterranean diet adherence that is recognized as an healthy diet to prevent non communicable diseases (NCD). Consequently, in 2016 in Tunisia, NCD accounted for 86% of all deaths, among which cardiovascular diseases (44%) and diabetes (5%) (WHO, 2018).

[INSERT Figure 2]

In this context, the objective of the study was to assess a better dietary scenario - bringing caloric intake to recommendations and respecting a large set of nutritional recommendations- on trade. To build this scenario, we used mathematical programming which is a tool commonly used in the scientific literature to reach optimal diets in terms of nutrition, cost, consumer preferences or environmental impacts. Initiated by economists (Stigler, 1945 and Smith, 1959), this methodology was taken up essentially by researchers in nutrition and nowadays the literature in agricultural, food or health economics and policy deploying this type of method is more rare. In, the Gazan et al (2018) literature review, out of 67 articles published, only 2 were published in economics journals. Apart from the seminal works of Stigler and Smith we can quote the works of Henson, 1991; Srinivasan *et al.*, 2006; Srinivasan, 2007; Shankar *et al.*, 2008; Arnoult *et al.*, 2010, Irz et al., 2015). This literature assessed the impact of optimizing the diet essentially on consumption and except the work of Arnoult *et al.* (2010) who translated dietary guidelines in agricultural production and land use, but no study adressed the impacts on food supply and more particularly on trade. Our approach complemented these works by enlarging the results at the country level and assessing their impact on international trade and thus on import dependency. Our goal was, using the approach described in Srinivasan (2007), to optimize the Tunisian apparent consumption under the ANSES (French agency for food, environmental and occupationnal health and safety) set of nutritional constraints (hereafter, NC; ANSES, 2016 p. 94) and synthetized in table A1 in Appendix. Then, once the optimized consumption identified, we used the GTAP Constant Elasticity of Substitution (CES) parameters (Dimaranan *et al.*, 2006) to evaluate the impact of the adherence to the NC on the Tunisian domestic and foreign supply of food.

The paper is organized as followed section 2 presents the sources and the matching of data, section 3 describes the model. Results are presented in section 4 and discussion and conclusion are provided in section 5.

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[2] food items (FAO, 2011) and two French databases on food contents in macro- and micronutrients: Ciqual (Ciqual, 2012) and Nutrinet (Nutrinet-Santé, 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 databases. 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

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

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 apparent intake in Tunisia in 2010 and the NC, we computed, as previously done by Hatloy *et al.* (1998) the Nutrient Adequacy Ratios (NAR)

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

Where N_j represents the observed intake of nutrient *j* and N_j' is the NC 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 FBS of Tunisia in 2010 have been used to estimate individual apparent consumption. Table A2 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 the apparent consumtion (defined as domestic production + imports – exports +/- stocks variations). 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. In Tunisia, the food availabilities are equivalent to 3,731 calories per inhabitant and per day. For this reason we did not use the quantities as the actual consumption of food. We kept the proportion of each item for a daily intake of 2,702 calories (see table A3 in Appendix) which corresponds of the mean adult daily intake in Tunisia (Perignon et al., 2017). This restriction to 2,702 calories is not undertaken via the model but is a simple beforehand proportional computation.

THE MODEL

We used the non-linear programming approach described in Srinivasan (2007) slightly modified. The simulations are made using the GAMS software. The model is composed of 62 foods items detailed in table A3 in Appendix, which represent the Tunisian diet observed in 2010 for 2,702 kcal. More accurately, it shows the food utilization of 62 items equivalents. We proceed in two steps. In a first step, we optimized a theoretical Tunisian food consumption to evaluate the diet quality and find out in what proportion the food items should vary to insure the adequacy with the nutritional recommendations. In the second step we applied these variations to the food supplies to assess what changes should be performed in terms of domestic production versus imports.

To identify these changes, 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 share of each item *i* consumption quantity in the total observed consumption quantity preventing the model to propose too much large variations in food relatively little being consumed.

$$Z = \sum_i \alpha_i \left(\frac{X_i' - X_i}{X_i} \right)^2$$

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

Z was minimized under a set of constraints, which corresponds to the NC recommendations summarized in table A1 in Appendix. The recommendations concerned 34 macro- and micronutrients. We eliminated sodium 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. The men/women median was considered as the minimum of nutrient constraint. The upper limits (where they exist) have been defined as the safety limits for some nutrients. Some additional constraints were taken into account to impede the model to increase or decrease too much the quantity of particular products like tea, coffee, spices or alcohol which have been fixed at their observed level.

Once the diet has been optimized we used the GTAP constant elasticity of substitution (CES) parameter in order to simulate the adoption of the NC recommendations on international trade and domestic supply. Following Armington (1969), we assumed the imperfect substitutability of products from domestic or foreign origins.

We computed the needed variations to insure an adequate diet these variations are equal to $\delta_i = \frac{x_i - x_i'}{x_i}$ and multiplied the food apparent consumption *FAC* (and not the diet) by these variations $FAC' = (1+\delta) * FAC$.

We then, computed d_i the ratios of imports to domestic demand for the different domestically produced goods:

$$d_i = \frac{Imports_i}{Domestic_i} = \left[\frac{PD_i}{PM_i}\frac{\beta_i}{\beta_i - 1}\right]^{\varepsilon_i}$$

In the GTAP database *PD* and *PM* are the same and equal to 1. Where ε_i is the elasticity of substitution of good *i*, PD_i and PM_i are respectively the prices or domestically produced and imported goods *i* and α_i the share parameter: $\beta_i = \frac{G}{1+G}$ and $G = \left(\frac{Imports_i}{Domestic_i}\right)^{\varepsilon_i}\frac{PM_i}{PD_i}$

This ratio will allow disentangling the share of local and foreign origin in the optimised food apparent consumption.

$$FAC'_{domestic} = \frac{FAC'}{1+d_i}$$

$$FAC'_{imported} = FAC'\frac{d_i}{1+d_i}$$

RESULTS

The simulation was done without considering age and gender but for an observed average adult consumption of 2,702 kcal per day and per person. First, decreasing the daily caloric intake from 3,731 to 2,702 kcal is a uniform decrease by 37% of each item. Then, we performed the simulations. The model simulates the optimized diet keeping the actual proportion of each item in the total consumption. Results are displayed in figures 4 and 5 for aggregated items. Detailed results are provided in tables A4 in Appendix.

Table 1 and figure 3 report the values of NAR_j for each macro- and micronutrient listed in the French NC. We confirmed that the mean Tunisian diet was too rich in carbohydrates and free sugar, while several nutrients were under the ANSES dietary recommendations: fibres, vitamins (A, B1, B2, B12, C and D), calcium, magnesium, zinc and iodine. Even if the *NAR* for free sugar is very close to 1, ideally the consumption of free sugar should be null or very low. 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. Carbohydrates, free sugar and other nutrients have adequately evolved (see table 1).

[INSERT Table 1]

[INSERT Figure 3]

[INSERT Figure 4]

[INSERT Figure 5]

Reaching nutritional adequacy induced a strong reduction of sugar including honey and sweeteners (almost 100%). The consumption of carbohydrates should not exceed 40% to 55% of the total energy on average according to the NC and free sugar should be limited to 10% of the total provision of calories. The FBS in 2010 displayed figures above these recommendations. The *NAR* is equal to 1.25-1.72 for carbohydrates but 1.11 for free sugar, for an intake of 2,702 kcal/day.

We have used the results of the simulation to compute the impact in terms of macro-data and particularly in terms of domestic versus foreign origin. We thus computed the new domestic supply and trade after the reallocation of food items towards an optimised diet at the national level (see figures 6 and 7 and table A5 in Appendix). In the scenario of adequate diet, Tunisia would decrease its foreign dependence in sugar and cereals but would increase its dependence in all other goods. But it is worth stressing that changes in food patterns would weigh on domestic agricultural production, which should be redirected towards the domestic market rather than towards export

Our modelling exercise almost completely eliminated free sugar from the diet except honey. In Tunisia sugar is largely supported by the food subsidy system and is totally imported from abroad. The second item to be reduced was cereals. Their consumption should be decreased by 44%, particularly wheat, which is the main cereal consumed in Tunisia. Wheat has also been supported by the Tunisian food subsidy system. Nowadays Tunisia is largely dependent on imports to ensure food security, especially the needs in cereals. These reductions are essentially met by decreasing imports by 600,000 tons of cereals and 350,000 tons of sugar (in raw sugar equivalent).

Interesting results concerned (i) the dramatic increase of products from animal origin: fish and seafood (+194%), meat and eggs (+148%, particularly eggs and red meats) and dairies (+107%) this is explained by the important deficit in calcium, the weak availability of iron and the lack of other minerals as zinc, magnesium and copper at baseline. The transition towards a Westernized diet seems to be not the main problem of Tunisians whose consumption of proteins from animal origin is not too high at baseline and could thus be increased. These shifts are based on the spectacular increase in domestic supply by 1,000,000 tons of milk, 222,000 tons of eggs and 100,000 tons of bovine meat and 142,000 tons of fish and seafood.

Concomitantly to the reduction in cereals, other plant products increased: legumes (+124%), fruits (+29%) and vegetables (+57%), even if the consumption of fruits and vegetables was already adequate at baseline. Such increases are probably due to achieve adequate recommendations in fibres, and compensate the reduction of fibres provided by cereals. They would also impact domestic production by +1,405,000 tons of various vegetables and +84,000 tons of legumes.

[INSERT Figure 6]

[INSERT Figure 7]

CONCLUSIONS

Nutritional transition in Tunisia (and in many countries) was often 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 often fail in delivering healthy diets. Our work proposed 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. The results of the optimisation show that if Tunisians would strictly adhere to the French nutrition recommendations, thus the country would decrease its dependence to international markets for sugar and cereal but would have to find the necessary means to cover its needs in products from animal origin, fruits, vegetables and legumes. This conclusion reinforces the needs to improve the sustainable productivity of agriculture and to redirect public funds.

In our scenario the strong increase in the consumption of certain products like products from animal origin, fruits, vegetables, and legumes is supposed to be met by an increase of the domestic supply. These results suppose that the factors (land, labor) released by the abandonment of the production of cereals would be available for other agricultural productions and mobile within the agricultural sector. This also implies that the domestic agricultural production should be reoriented towards the domestic market.

In this analysis we used the mathematical programming model described in Srinivasan (2007) to represent and simulate changes in the Tunisian diet average pattern. Using data from the FBS in 2010 we computed a reduction of the average caloric intake from 3,731 to 2,702 kcal per person and per day keeping the share of each item constant. Then we optimized the diet to respect the adequacy with the French recommendations (NC) on macro- and micronutrients. Finally, we recalculated the needs for each food items and the impact of these diet recommendations in terms of foreign and domestic origin (detailed results are provided in table A5 in Appendix).

1- A first analysis of the Tunisian diet computing the ratios of nutrient adequacies showed that, the Tunisian diet is almost adequate (according to the ANSES set of nutritional recommendation constraints) but was too rich in free sugars and insufficient in fibres, certain vitamins and minerals.
2- Results of the optimization showed that the consumption of sugar and wheat must be reduced. But all other food categories of the diet must be increased to achieve the nutritional references.
3- As a consequence, the adherence to nutritional recommendations would have impacts at macro-level to ensure food security. The reduction in cereals and sugars would induce a decrease of 600,000 tons of cereals and of 350,000 tons of raw sugar equivalent imports.
4- But, in order to maintain a safe level of calcium, iron and proteins, the results of the modelling do recommend an increase in the consumption of products from animal origin particularly dairy products (essentially milk) which imports would increase by 159,000 tons, but also fish and seafood (+63,000 tons), meats and eggs (+13,000 tons).

5- Finally, in line with the deficiency in several vitamins and fibres, Tunisian consumers should increase their intakes of legumes, fruits and vegetables. It implies an increase in the importations of vegetables (+20,000 tons), legumes (+14,000 tons) and fruits (+9,000 tons).

Such modelling is useful to re-orientate the current public policies. 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. Our work suggested that encouraging people to improve their diet may have impact at a macro-level. Governments should rethink their food policies in a comprehensive way to improve food accessibility, quality and sustainability. Reducing the consumption of sugars and refined starchy foods would require strong nutritional policy actions aimed at jointly promoting public health goals of NCD prevention and limiting the risks associated to high levels of food dependence (Le Mouel and Schmitt, 2018).

To reduce agricultural import dependence, it is necessary to integrate other actions than those promoting a better diet. To ensure food and nutritional security, it is necessary to implement agricultural policies favouring the adoption of nutritional-sensitive agriculture and technical innovations, improving agronomic and zootechnical practices, and facing the climate change. Moreover, policies should address the reduction of waste and losses. In conclusion, the combination of a better adherence to a healthy diet, and improvement of agriculture practices and the avoidance of losses could slow the rise of agricultural import dependence.

However, our work had several limits. 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. The model of trade used was static and did not include prices or budget constraint thus the ability of Tunisians to switch from one diet to another has to be analysed in the future nor did it include an analysis of production capacity.

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APPENDIX

[INSERT Table A1]

[INSERT Table A2]

[INSERT Table A3]

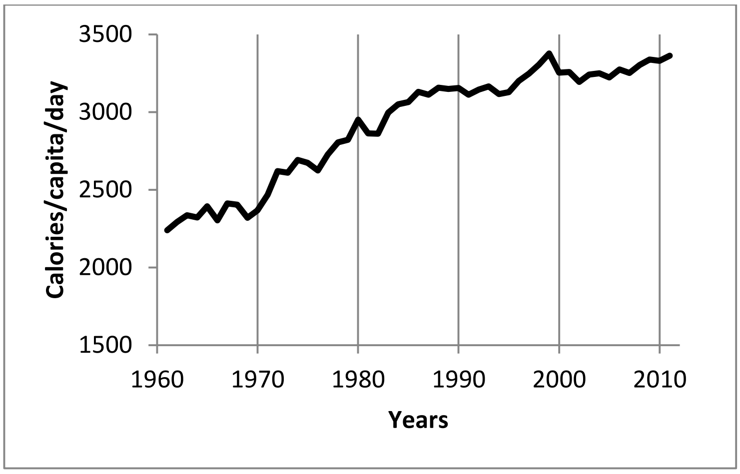
[INSERT Table A4]

[INSERT Table A5]

Table 1. Observed and optimized Nutrient Adequacy Ratios

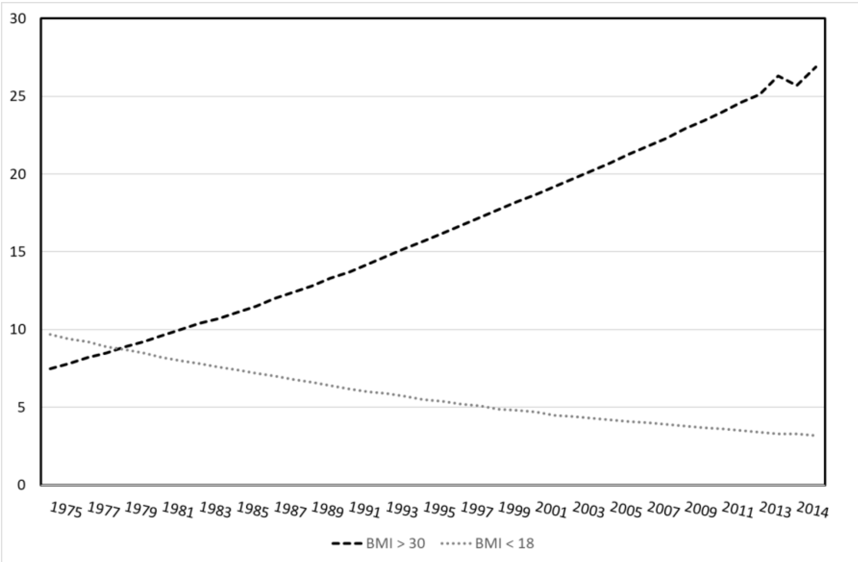
Nutrients	NAR_j for observed average diet	NAR_j after optimization
Calories	1.1	1
Proteins	1.42 - 0.71	1.96 - 0.98
Total fats	0.88 - 0.61	1 - 0.88
Carbohydrates	1.72 - 1.25	0.65 - 0.89
Linoleic acid	1.73	1.84
Linolenic acid	1.68	1.53
EPA + DHA	0.61	1.63
Saturated fatty acids	0.5	0.69
Free sugar	1.11	0
Fibres	0.63	1
Vitamin A	1.35 - 0.32	2.26 - 0.53
Vitamin B1	0.74	1.03
Vitamin B2	0.7	1.21
Vitamin B3	1.55 - 0.03	1.94 - 0.04
Vitamin B6	1 - 0.07	1.44 - 0.1
Vitamin B9	1.05	1.56
Vitamin B12	0.93	2.37
Vitamin C	0.91 - 0.09	1.3 - 0.13
Vitamin D	0.67 - 0.07	1.77 - 0.18
Calcium	0.56 - 0.22	1 - 0
Phosphorus	1.53	2.28
Potassium	1.18	1.74
Iron	1.14	1.6
Magnesium	0.77	1.11
Zinc	0.67 - 0.33	1 - 0.5
Selenium	1.12 - 0.26	1.74 - 0.41
Copper	1.21 - 0.27	1.58 - 0.36
Iodine	0.64 - 0.16	1 - 0.25

Figure 1. Apparent consumption in calories, evolution in Tunisia from 1960 to 2010



Source: Data from FAOSTAT

Figure 2. Prevalence of underweight (BMI < 18) and obesity (BMI > 30) in adult population in percentage (Tunisia, 1975-2015)



Source: data from the World Health Organization, BMI = Body Mass Index

375 **Figure 3. NAR for selected nutrients in the observed diet**

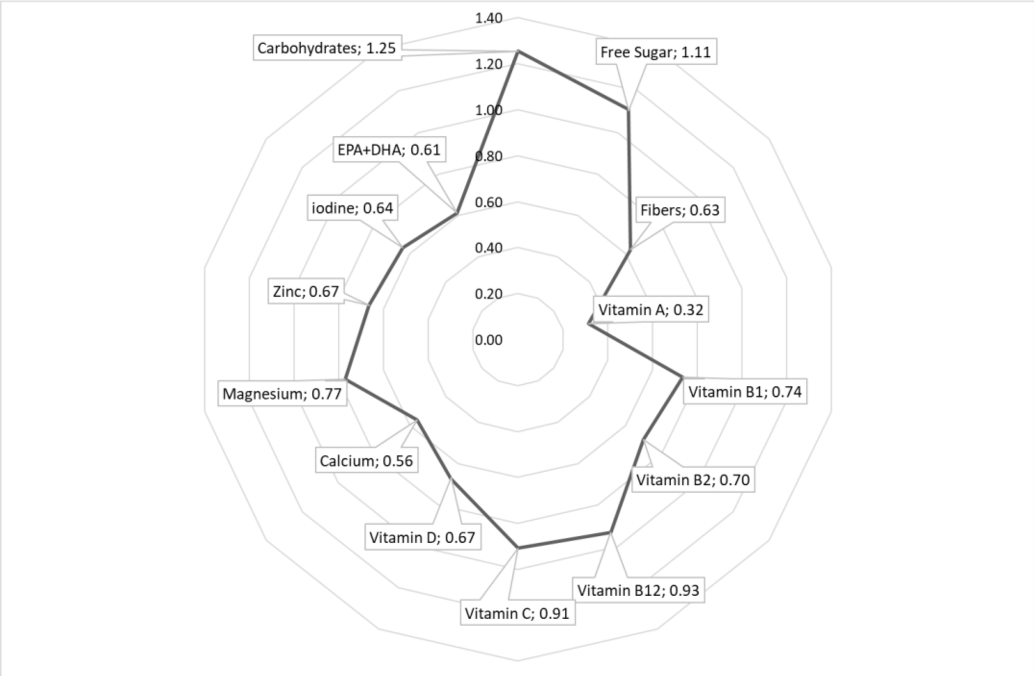


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Figure 4. Consumption in grams per day and per person at baseline and after optimization (all products)

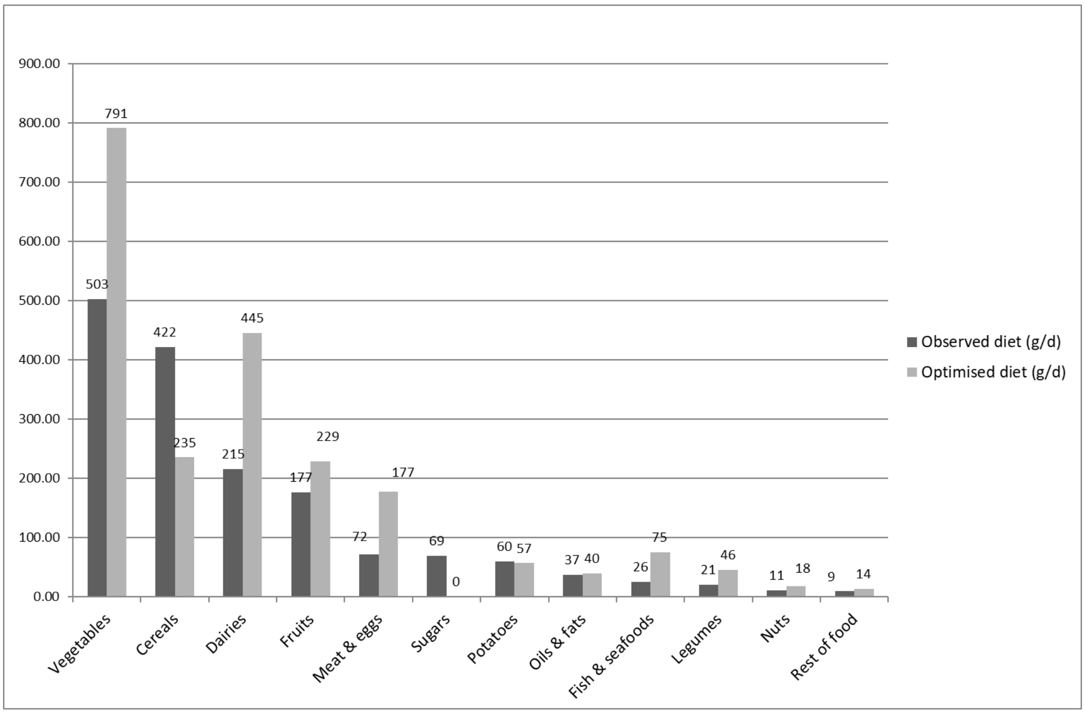


Figure 5. Consumption in grams per day and per person at baseline and after optimization (products from animal origin)

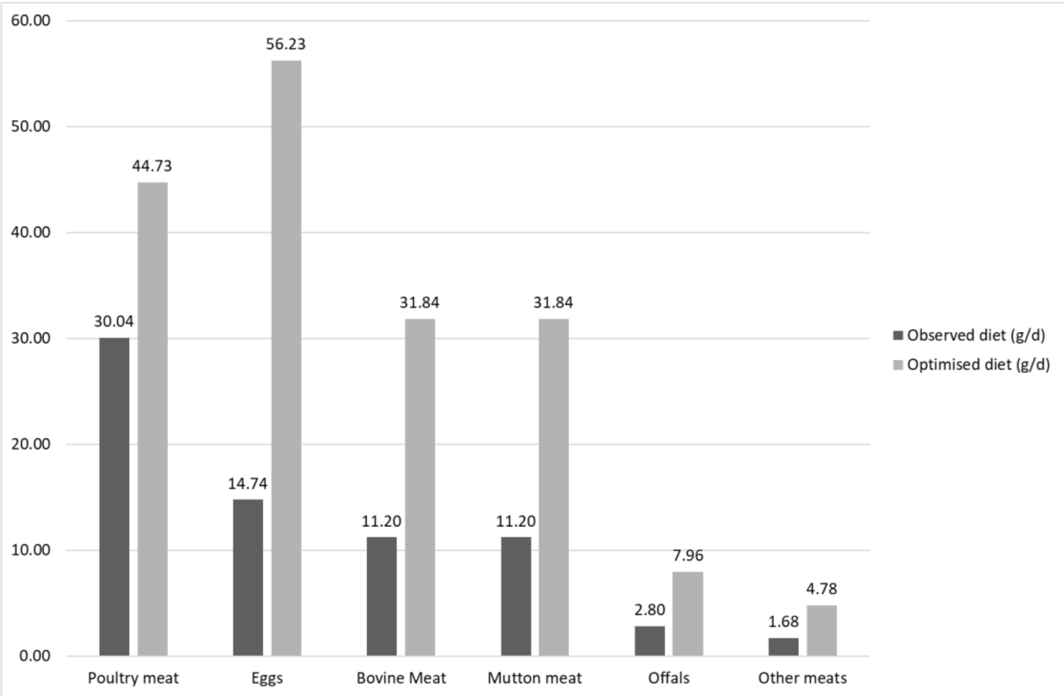
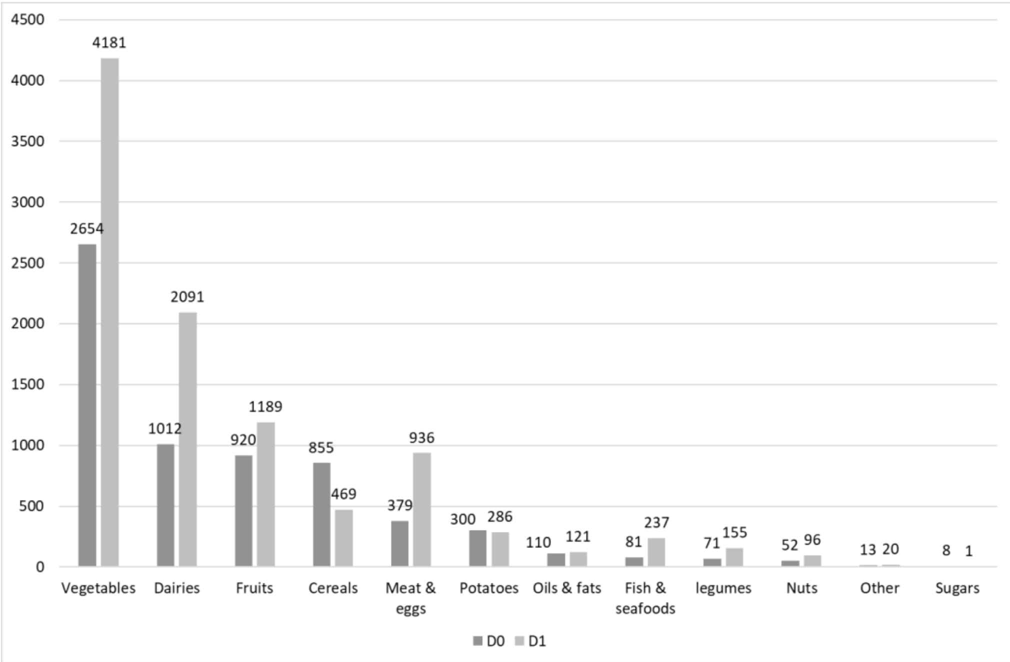


Figure 6. variations of domestic demand in 1000 tons (D0 observed demand, D1 demand after optimization)



389 **Figure 7. variations of imports in 1000 tons (M0 observed imports, M1 imports after optimization)**

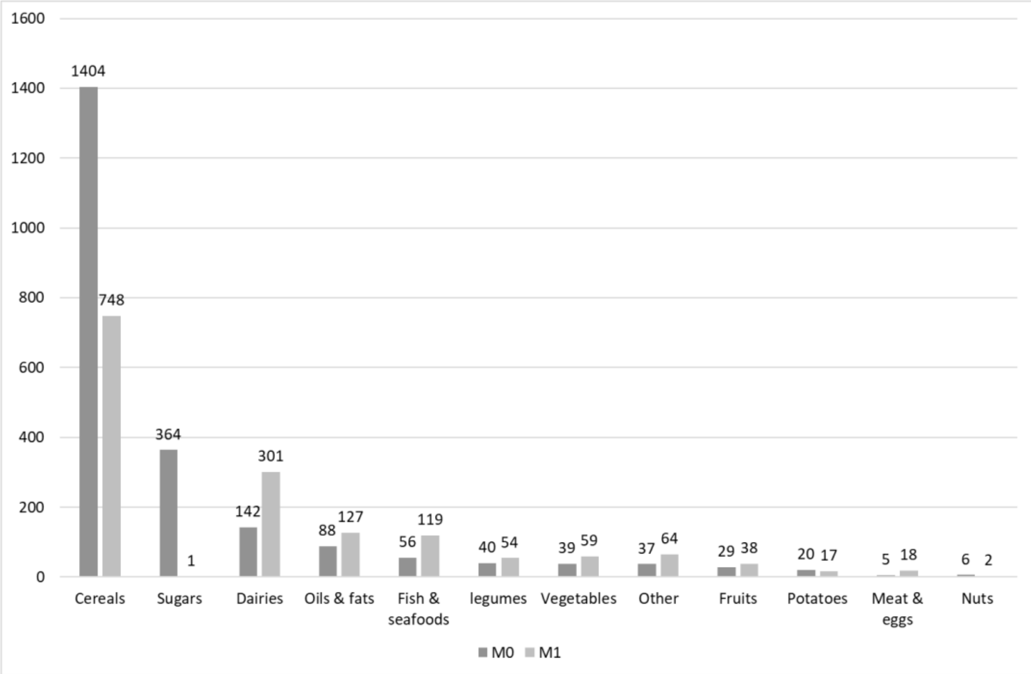


Table A1. ANSES daily nutritional recommendations (NC)

Nutrient	Lower limits	Upper (or safety) limits
Protein (% total energy)	≥ 10	< 20
Total fats (% total energy)	≥ 35	< 40
Carbohydrates (% total energy)	≥ 40	< 55
Linoleic acid (% total energy)	≥ 4	--
Linolenic acid (% total energy)	≥ 1	--
EPA+DHA (mg)	≥ 500	--
Saturated fatty acids (% total energy)	--	< 12
Free Sugar (% total energy)	--	< 10
Sodium (mg)	--	< 2633.5
Fibers (g)	≥ 30	--
Vitamin A (µg/d)	≥ 700	≤ 3000
Vitamin B1 (mg/kcal)	≥ 0.00058	--
Vitamin B2 (mg/kcal)	≥ 0.00071	--
Vitamin B3 (mg eq. niacin/kcal)	≥ 0.0067	≤ 47
Vitamin B6 (mg)	≥ 1.65	< 25
Vitamin B9 (µg eq. folate)	≥ 330	--
Vitamin B12 (µg)	≥ 4	--
Vitamin C (mg)	≥ 110	--
Vitamin E (mg)	--	< 300
Vitamin D (µg)[3]	≥ 3	< 50
Calcium (mg)	≥ 900	--
Phosphorus (mg)	≥ 700	--
Potassium (mg)	≥ 2633.5	--
Iron (mg)	≥ 11	--
Magnesium (mg)	≥ 390	--
Zinc (mg)	≥ 12.5	< 25
Copper (mg)	≥ 1.125	< 5
Iodine (µg)	≥ 150	< 600
Selenium (µg)	≥ 70	≤ 300
Total energy (kcal/d)	--	2467.5

Source: ANSES (2016)

[3] The constraint on vitamin D was too strict and made the model infeasible, we thus kept the previous lower limit of 3µg.

Table A2. Observed apparent consumption (3,731 kcal)

Items	Daily apparent consumption of food (g/cap.)	Items	Daily apparent consumption of food (g/cap.)
Apples	28.77	Molluscs	0.27
Bananas	4.38	Mutton Meat	15.62
Barley	15.89	Nuts	13.70
Beans	1.64	Offal	4.11
Bovine Meat	15.62	Oilcrops Oil	0.55
Butter	1.64	Olive Oil	8.22
Cephalopods	0.27	Onions	33.97
Cereals	2.47	Oranges	35.62
Citrus	24.93	Palm Oil	6.30
Cocoa	1.10	Peas	3.84
Coconut Oil	1.10	Pelagic Fish	25.21
Coffee	4.93	Pimento	0.27
Cream	2.74	Pineapples	0.27
Crustaceans	0.27	Potatoes	82.47
Dates	15.34	Poultry Meat	41.64
Demersal Fish	7.95	Pulses	18.63
Eggs	20.27	Rapeseed Oil	1.37
Fats	0.55	Rice	2.47
Freshwater Fish	0.55	Sorghum	1.64
Fruits	90.41	Soybean Oil	27.40
Grapefruit	19.73	Soybeans	4.11
Grapes	16.16	Spices	4.38
Groundnuts	1.37	Sugar	92.60
Honey	1.10	Sunflowerseed Oil	2.74
Lemons	8.49	Sweeteners	2.19
Maize Oil	1.64	Tea	2.74
Marine Fish	0.82	Tomatoes	297.26
Meat	2.47	Vegetables	362.74
Milk	294.79	Wheat	559.45

Source: FAOSTAT Food Balance Sheets

Table A3. Observed diet for 2,702 kcal

Items	Daily guestimates of consumption (g/cap.)	Items	Daily guestimates of consumption (g/cap.)
Apples	20.90	Molluscs	0.19
Bananas	3.17	MuttonMeat	11.20
Barley	11.57	Nuts	9.89
Beans	1.12	Offals	2.80
BovineMeat	11.20	OilcropsOil	0.37
Butter	1.12	OliveOil	5.97
Cephalopods	0.19	Onions	24.63
Cereals	1.87	Oranges	25.75
Citrus	18.10	PalmOil	4.48
Cocoa	0.75	Peas	2.80
CoconutOil	0.75	PelagicFish	18.29
Coffee	3.55	Pimento	0.19
Cream	1.87	Pineapples	0.19
Crustaceans	0.19	Potatoes	59.71
Dates	11.01	PoultryMeat	30.04
DemersalFish	5.78	Pulses	13.62
Eggs	14.74	RapeOil	0.93
Fats	0.37	Rice	1.87
FreshwaterFish	0.37	Sorghum	1.12
Fruits	65.50	SoyabeanOil	19.78
Grapefruit	14.37	Soyabeans	2.99
Grapes	11.76	Spices	3.17
Groundnuts	0.93	Sugar	66.99
Honey	0.75	Sunflowerseed Oil	2.05
Lemons	6.16	Sweeteners	1.68
MaizeOil	1.12	Tea	1.87
MarineFish	0.56	Tomatoes	215.15
Meat	1.68	Vegetables	262.55
Milk	213.47	Wheat	405.11

Source: Authors own calculations based on FAOSTAT Food Balance Sheets

Table A4. Optimized diet for 2,467.5 kcal

Items	Opt. consumption (g/d)	% variation	Items	Opt. consumption (g/d)	% variation
Apples	25.14	20.29	Molluscs	1.84	886.40
Bananas	3.73	17.58	MuttonMeat	31.84	184.38
Barley	11.36	-1.79	Nuts	18.30	85.03
Beans	2.78	148.40	Offals	7.96	184.38
BovineMeat	31.84	184.38	OilcropsOil	0.39	4.29
Butter	1.32	18.16	OliveOil	6.20	3.91
Cephalopods	0.64	243.46	Onions	35.15	42.69
Cereals	1.00	-46.28	Oranges	35.28	36.99
Citrus	24.80	36.99	PalmOil	4.53	1.17
Cocoa	3.31	343.08	Peas	6.68	138.71
CoconutOil	0.78	4.29	PelagicFish	53.13	190.52
Coffee	3.81	7.41	Pimento	0.15	-17.10
Cream	3.51	87.90	Pineapples	0.28	49.38
Crustaceans	0.72	288.22	Potatoes	56.85	-4.80
Dates	17.05	54.91	PoultryMeat	44.73	48.88
DemersalFish	16.16	179.32	Pulses	29.30	115.10
Eggs	56.23	281.41	RapeOil	0.98	5.43
Fats	0.44	18.16	Rice	4.13	121.28
FreshwaterFish	1.04	179.32	Sorghum	1.24	10.79
Fruits	85.12	29.96	SoyabeanOil	21.97	11.09
Grapefruit	17.58	22.33	Soyabeans	7.25	142.95
Grapes	11.21	-4.61	Spices	4.76	50.00
Groundnuts	0.10	-89.28	Sugar	0.10	-99.85
Honey	0.10	-86.60	Sunflowerseed Oil	2.15	4.95
Lemons	8.37	35.95	Sweeteners	0.10	-94.05
MaizeOil	1.18	5.43	Tea	2.03	8.68
MarineFish	1.56	179.32	Tomatoes	295.79	37.48
Meat	4.78	184.38	Vegetables	459.89	75.16
Milk	441.53	106.83	Wheat	217.61	-46.28

Table A5. Production, trade and apparent consumption by food item in 1000 tons

Items	Observed food apparent consumption	Optimized food apparent consumption	Observed Production	Domestic origin of optimized food apparent consumption.	Observed Importation	Importation of optimized food apparent consumption
Wheat and products	2171	1166	822	442	1349	725
Rice (Milled Equivalent)	10	22		0	10	22
Barley and products	62	61	237	21	40	40
Sorghum and products	6	7	1	1	5	6
Cereals, Other	10	5	48	5	0	0
Potatoes and products	320	305	370	286	20	19
Sugar (Raw Equivalent)	359	1	0	0	359	1
Sweeteners, Other	9	1	4	0	5	0
Honey	4	1	4	1	0	0
Beans	6	15	0	0	6	15
Peas	15	36	13	31	2	5
Pulses, Other and products	73	157	78	124	16	33
Nuts and products	53	98	54	96	1	2
Soybeans	16	39		0	16	39
Groundnuts (Shelled Eq)	5	1		0	5	1
Soybean Oil	106	118	68	76	38	42
Sunflower seed Oil	11	12	2	2	9	9
Rape and Mustard Oil	5	5		0	5	5
Palm Oil	24	24		0	24	24
Coconut Oil	4	4		0	4	4
Olive Oil	32	33	196	33	0	0
Maize Germ Oil	6	6		0	6	6
Oil crops Oil, Other	2	2	2	1	2	2
Tomatoes and products	1153	1585	1296	1550	25	35

Items	Observed food apparent consumption (3684 kcal)	Optimized food apparent consumption (3684 kcal)	Observed Production	Domestic origin of optimized food apparent consumption.	Observed Importation	Importation of optimized food apparent consumption
Onions	132	188	147	188	0	0
Vegetables, Other	1407	2465	1667	2441	13	23
Oranges, Tangerines	138	189	174	179	8	10
Lemons, Limes and products	33	45	37	45	0	0
Grapefruit and products	77	94	87	94	0	0
Citrus, Other	97	133	104	133	0	0
Bananas	17	20		0	17	20
Apples and products	112	135	126	131	3	4
Pineapples and products	1	1		0	1	1
Dates	59	91	174	91	0	0
Grapes and products (excl wine)	63	60	97	60	0	0
Fruit, Other	351	456	423	456	0	0
Coffee and products	19	20		0	19	20
Cocoa Beans and products	4	18		0	4	18
Tea (including mate)	10	11		0	10	11
Pimento	1	1	12	1	0	0
Spices, Other	17	26	13	20	4	6
Bovine Meat	60	171	56	159	4	11
Mutton & Goat Meat	60	171	59	168	1	3
Poultry Meat	161	240	161	240	0	0
Meat, Other	9	26	10	26	0	0
Offal, Edible	15	43	15	43	0	0
Butter, Ghee	6	7	6	7	0	0
Cream	10	19	20	19	0	0
Fats, Animals, Raw	2	2	6	2	0	0
Eggs	79	301	92	301	0	0
Milk - Excluding Butter	1144	2366	1069	2072	142	294

Items	Observed food apparent consumption (3684 kcal)	Optimized food apparent consumption (3684 kcal)	Observed Production	Domestic origin of optimized food apparent consumption.	Observed Importation	Importation of optimized food apparent consumption
Freshwater Fish	2	6	2	6	0	0
Demersal Fish	31	87	29	81	2	6
Pelagic Fish	98	285	58	131	53	154
Marine Fish, Other	3	8	3	8	0	0
Crustaceans	1	4	3	3	0	1
Cephalopods	1	3	7	3	0	0
Mollusks, Other	1	10	1	5	1	5

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