Estimating Food Consumption Changes for Transition to Healthy Diets in the UK

TUKFS SPF Project: Realigning UK Food Production and Trade for Transition to Healthy and Sustainable Diets
Work Package 1

Introduction

Faced with the increasing incidence of obesity and diet-related disease, the promotion of healthier diets for consumers that conform to recommended dietary guidelines has become an important public health priority in the UK. The UK Cabinet Office Report Food Matters (Jarvis 2008) identifies the promotion of healthier dietary choices by consumers as a key element in the Government's food strategy for the 21st century. This follows from the recognition of the enormous health gains that would accrue to the UK if diets matched nutritional guidelines on fruit and vegetable consumption, saturated fats, added sugars, fibre and salt intake. The report estimates that adherence to nutritional guidelines would reduce the risks related to cancer, heart disease and other illnesses leading to 70,000 fewer people dying prematurely every year. Improved dietary choices are also crucial for meeting the challenge of obesity, with a quarter of adults and 10% of children in the UK already classified as "obese" (Public Health England, 2018). In addition to the social impacts, the economic burden of diet related ill-health is estimated at almost £6 billion a year by way of additional National Health Service costs alone (Jarvis, 2008).

In this paper we model the changes in consumption of different food products that would be required in the UK for a transition to "healthy" diets. We conceptualise the transition to healthy diets as a shift to dietary consumption patterns of existing food products that conforms to the recommended dietary guidelines.

WHO and UK Dietary Guidelines

In 2004, the member countries of the World Health Organization (WHO) endorsed its Global Strategy on Diet, Physical Activity and Health. The strategy, adopted after considerable debate, called for limiting the consumption of saturated fats, cholesterol, salt and sugars, and to increase the consumption of fruit and vegetables in order to combat the growing burden of non-communicable disease. The recommended dietary guidelines, emerged from an extensive review of the medical and nutrition literature examining the relationship between dietary choices/nutrient intakes and the prevalence of chronic disease and ill-health. They are intended to reduce the incidence of a range of chronic diseases such as diabetes mellitus, cardiovascular disease, hypertension, stroke, certain types of cancer and combat obesity. The rising trend in the obesity and non-communicable disease has been associated with significant deviations from the recommended guidelines suggested by the WHO (WHO, 2003). Dietary guidelines of the World Health Organization (WHO, 2003) are chiefly related to the share of energy derived from macronutrients (fats and sub-components, sugars and protein) and the absolute intake levels of fruits and vegetables, fibre, salt and cholesterol (Table-1).

Dietary guidelines in the UK (Department of Health, 1991) (Table -1) are aligned fairly closely with the WHO guidelines and underpin public health interventions to promote healthier diets. These interventions have sought to influence both consumer demand (intakes) for different nutrients as well as the supply of nutrients through food products offered to consumers by industry.

Table-1 WHO and UK Recommended Dietary Intake Guidelines

Dietary factor	Goals	
	WHO guidelines	UK dietary guidelines[d]
	(% of total energy intake)	
Total fats	15-30%	35%
Saturated fatty acids	<10%	<11%
Polyunsaturated fatty acids (PUFAs)	6-10%	>6.5%
n-6 Polyunsaturated fatty acids (PUFAs)	5-8%	-
n-3 Polyunsaturated fatty acids (PUFAs)	1-2%	-
Transfatty acids	<1%	-
Monosaturated fatty acids (MUFAs)	By difference[a]	13%
Total carbohydrate	55-75%[b]	50%
Free sugars[c]	<5%	<5%
Protein	10-15%	8-10%
	(Daily consumption)	
Cholesterol	<300 mg/day	-
Salt	< 5 gms/day	6 gms /day
Fruits and vegetables	>= 400 gms/day	
Total dietary fibre (from foods)		>= 30 gms per day

[a] This means "total fat – (saturated fatty acids + polyunsaturated fatty acids + trans fatty acids)".

[b] The percentage of total energy available after taking into account that consumed as protein and fat, hence the wide range.

[c] The term "free sugars" refers to all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey syrups and fruit juices. In UK datasets, this broadly corresponds to "non-milk extrinsic sugars".

[d] The UK dietary guidelines (Public Health England, 2016) also contain recommended dietary intakes for vitamins (Vitamin A, Thiamin, Riboflavin, Niacin equivalent, Vitamin B6, Vitamin B12 Folate, Vitamin C and Vitamin D) and minerals (Iron, Calcium, Magnesium, Potassium, Zinc, Copper, Iodine, Selenium, Phosphorus, Chloride, Sodium) for different age-groups for males and females.

Source: WHO (2003), UK Department of Health (1991), Public Health England (2016)

In the analysis that follows, we use the WHO guidelines as the benchmarks for healthy diets as that will make it easier for comparing the results for the UK with studies for other countries which are based on the WHO dietary guidelines. The UK guidelines are also closely aligned with the WHO guidelines except that the total fat constraint (percentage of energy derived from all fats) is more stringent under the WHO guidelines (30%) than it is under the UK guidelines (35%). The WHO guidelines do not prescribe a specific value for consumption of dietary fibre. We use the dietary fibre recommendation of 30 gms per day (calculated by the Southgate method) as the benchmark for healthy diets. We have not considered any constraint related to the consumption of micronutrients (vitamins and minerals) in the analysis, as the aggregate level data for UK do not show any deficiency in the consumption of micronutrients and the changed diets emerging from the analysis are unlikely to violate the recommendations for consumption of micronutrients. However, the analysis can be easily extended to incorporate micronutrient consumption constraints. We have not included any cholesterol constraint in the analysis as the UK guidelines do not include a cholesterol constraint and the cholesterol constraint has recently been dropped by the USDA in dietary guidelines for the US.

Dietary Interventions for Influencing Consumer Dietary Choice

Several public health interventions in the UK have sought to influence both consumer intakes (demand) for different nutrients as well as the supply of nutrients through food products offered to consumers by industry. Information campaigns have sought to promote healthier dietary choices by consumers. Dietary interventions have also sought to influence the intakes of specific dietary elements. The UK Government's "Five-a-Day"[1] campaign to increase the consumption of fruits and vegetables and the European Union's Salt Campaign[2] are important examples of such approaches. Nutritional labelling schemes (e.g., traffic-light labelling schemes for processed foods) seek to shift consumer choices towards healthier options of processed food products. Fiscal measures (e.g., the UK's sugar tax from 2018[3]) have also been instituted to discourage the excess consumption of certain nutrients. On the supply side, "Responsibility Deals"[4] seek to nudge the food industry towards offering healthier choices to consumers. While nutritional guidelines for healthy eating specify the aggregate daily intakes of macronutrients and other dietary elements, consumers' choice in relation to diets is exercised at the level of individual food groups or food products. The aggregate intake of nutrients and the adherence/non-adherence to recommended nutritional guidelines is an outcome derived from the consumers' choices of a large number of food products. Most consumers may not be aware (or may be unable to gauge) how their choice of food products translates into aggregate nutrient intakes. Interventions to promote healthier eating, including information campaigns, therefore, need to address the overall dietary patterns of consumers. Consumers need guidance on how their overall food consumption basket needs to change in order to achieve conformity to dietary guidelines. The UK Government's "Eatwell Plate"[5] and the US Government's "MyPlate"[6] are examples of dietary recommendations based on a desirable combination of different (broadly defined) food groups. The recommended dietary patterns, which involve combinations of different food groups/products are expected to allow consumers to achieve better conformity with nutritional guidelines.

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[1] The UK's 5 A DAY campaign, introduced in 2002–2003, aims to increase awareness of the health benefits of fruit and vegetable consumption, particularly targeting groups with the lowest intakes. For key messages and targeted action under the programme, see http://www.nhs.uk/LiveWell/5ADAY/Pages/5ADAYhome.aspx

[2] The European Union adopted a "Common Framework for National Salt Initiatives" in 2008 with the objective of reducing the salt content of food products, also encompassing salt consumed in restaurants and catering (European Commission, 2012). For details of implementation of the salt reduction initiative see http://ec.europa.eu/health/nutrition_physical_activity/high_level_group/nutrition_salt_en.htm

[3] The UK Government introduced a new levy on the production and important of soft drinks containing added sugar from April 2018. The levy was applied at a lower rate on drinks with added sugar content of more than 5 g per 100 ml and a higher rate for drinks with 8 g per 100 ml or more. The policy objective was to encourage the industry to reformulate their products to reduce the sugar content and encourage consumers to move towards healthier choices. https://www.gov.uk/government/publications/soft-drinks-industry-levy/soft-drinks-industry-levy.

[4] Public Health Responsibility Deals for food are an initiative of the UK Department of Health under which industry partners voluntarily undertake to promote healthier options of food products with lower calorie content, saturated fats, salt and elimination of transfats. Currently more than 400 industry partners have signed up to the Responsibility Deals for food. See https://responsibilitydeal.dh.gov.uk/

[5] The UK Government's "Eatwell Guide" shows how much of what consumers eat should come from different food groups to achieve a healthy, balanced diet. See http://www.nhs.uk/Livewell/Goodfood/Pages/the-eatwell-guide.aspx

[6] MyPlate" is a communications initiative based on the 2010 Dietary Guidelines for Americans (US Department of Health and US Department of Health and Human Services, 2010) to help US consumers to make healthier food choices. See http://www.choosemyplate.gov/ for details of the initiative.

Methods

We start by calculating the current status of adherence to different WHO dietary guidelines in UK and then estimate the dietary changes required to bring diets in conformity with these norms. The WHO norms are expressed in terms of the nutrient and energy contents of diets and do not impose restrictions on the consumption of individual food items. Energy and nutrients are derived from a large number of food products and, therefore, a large number of diets that conform to the norms are theoretically possible. Estimating reformulations of diets in response to nutritional constraints, therefore, requires the construction of a model. We use a mathematical programming approach to predict the changes in food consumption most likely to occur if consumers were to adhere to the WHO norms. Given the persistence of dietary patterns and preferences, our analysis assumes that in adjusting their consumption of food products to adhere to these norms, consumers will prefer to modify their current diet as little as possible. Given that we abstract from direct consideration of costs in our model, we assume that our approach of minimizing deviations from current diets produces results that are not significantly dissimilar from those that would be obtained under least cost diet reformulation.

We use a quadratic programming (QP) approach where squared deviations from actual consumption levels are minimised while satisfying nutritional constraints. This approach is based on the paradigm that consumer preference and palatability considerations are manifested in the observed food choice. Radical changes from the observed choices are unrealistic, and hence deviations from the original diet are made as small as possible when estimating the new diet that meets the nutritional constraints.

The objective function of the QP model can be described formally as follows:

$$Min \ \sum_{i \in F} \propto_i \left(\frac{x_i' - x_i}{x_i} \right)^2, \text{where} \propto_i = \frac{e_i x_i}{\sum_{i \in F} e_i x_i} \quad \text{............................... (1)}$$

The objective function is the weighted sum of the squared deviations between the components (quantities in grams) of the optimised diet x_i' and the observed one x_i. Deviations are expressed in percentage terms. This prevents an unnatural situation where items that are consumed relatively in small amounts at the baseline expand or contract in large percentage terms when the diet is reformulated. The weights $\propto_i$ are the contributions of the food products to the original energy intake, which are computed from the calorific coefficients e_i for each food item x_i. All quantities are expressed in grams per capita per day and energy values in Kilo cals. The objective function is minimised over the whole set F of food items originally consumed subject to several nutritional constraints. The first three constraints state that in accordance with WHO norms, energy from all fats, protein and saturated fats should not exceed 30%, 15% and 10% of total calorific availability, respectively:

$$9 \sum_{i \in F} f_i x_i' \ \leq 0.3 \ \sum_{i \in F} e_i \ x_i' \ \text{.. (2)}$$

$$4 \sum_{i \in F} p_i x_i' \ \leq 0.15 \ \sum_{i \in F} e_i \ x_i' \ \text{... (3)}$$

$$9 \sum_{i \in F} s_i x_i' \ \leq 0.1 \ \sum_{i \in F} e_i \ x_i' \ \text{... (4)}$$

Where f_i, p_i and s_i denote the conversion coefficient of food item *i* into fat, protein and saturated fat respectively. Note that 1gm of fat yields 9 calories while 1 gm of protein, sugar or carbohydrate

yields 4 calories. The fourth constraint restricts poly-unsaturated fatty acids (PUFA) to a range of 6-10% of energy. Thus, where r_i is the PUFA conversion factor of food item I,

$$0.06 \sum_{i \in F} e_i x_i' \leq 9 \sum_{i \in F} r_i \ x_i' \leq 0.1 \sum_{i \in F} e_i \ x_i' \ \dots\dots\dots\dots\dots\dots\dots\dots\dots(5)$$

The requirements in table 1 regarding mono-unsaturated fats and carbohydrates are met automatically (by difference) given the above constraints.

The next constraint restricts energy derived from "free sugars" (for the UK we use "non-milk extrinsic sugars") to a maximum of 5% of total energy intake. Thus, where n_i is the conversion coefficient of food item i into "non-milk extrinsic sugars",

$$4 \sum_{i \in F} n_i x_i' \leq 0.05 \sum_{i \in F} e_i \ x_i' \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(6)$$

The next constraint imposes a minimum daily per capita consumption of 400 gms of fruits and vegetables.

$$400 \leq \ \sum_{i \in V} x_i' \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(7)$$

Where V is the subset of food items that are either fruits or vegetables.

The next constraint imposes a constraint on the total consumption of salt of not more than 6gms per capita per day – expressed as a sodium constraint of 2.4 gms per day (sodium constitutes 40% of salt in the form of sodium chloride). Thus where k_i is the sodium conversion factor for food item i,

$$\sum_{i \in F} k_i x_i' \leq 2.4 \ gms \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(8)$$

The next constrain imposes a minimum consumption of dietary fibre (calculated as per the AOAC/Southgate method) of 30 gms per capita per day. Thus where g_i is the dietary fibre conversion factor for food item i

$$\sum_{i \in F} g_i x_i' \leq 30 \ gms \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(9)$$

We did not use a constraint for cholesterol consumption as the UK currently does not have a guideline for cholesterol consumption. UK dietary guidelines contain recommendations for micronutrient consumption. We did not apply any constraints related to micronutrients as UK consumption data does not show the prevalence of inadequate micronutrient consumption. While the above constraints are derived from the WHO/UK dietary norms, we added another constraint that restricts the increase in the consumption of any item to less than 300% of its level in the current diet. This constraint was added in order to preserve the diversity of the optimised diets and prevent the optimisation procedure from generating diets with only a small number of items from the original diet. Thus,

$$x_i' \leq 3x_i \text{ for all food items } i \in F \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(10)$$

We also include a constraint that the consumption of alcoholic drinks should not increase as a result of the optimisation of the diet. Thus

$$x_i' \leq x_i \text{ for all food items } i \in A \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(11)$$

where A is the subset of food items covering alcoholic drinks.

Data

We use the Living Cost and Food Survey (LCFS) for the UK conducted by the Office for National Statistics (ONS) and the Department for Food, Environment and Rural Affairs (DEFRA). This is a continuous survey of household expenditure, food consumption and income conducted across the whole of the UK and is the most significant survey on household spending in the UK. The annual statistics on food and drink purchases in the UK, derived from the Family Food Module of the LCFS are reported separately as part of DEFRA's Family Food datasets. It is the source of detailed statistical information on purchased quantities and expenditures derived from household and eating out food and drink. Data is collected for a nationally representative sample of households in the UK using self-reported diaries supported by till receipts of all purchases, including food eaten out over a two week period. The unit of consumption for the consumption aspects of the survey is the household and the survey reports household food and food eaten out analysed by region and demographic characteristics (household composition, income quintiles, age of household reference person, education, occupation, ethnic origin and economic status).

The data used in this estimation are from the Family Food statistics for the year 2019-20. The year 2019-20 was chosen for the estimation as the data for subsequent years, 2020-21 and 2021-22 may reflect some impacts of the Covid-19 pandemic and related restrictions on dietary choices of households. In 2019-20, data was collected from 5072 households. The individuals sampled in these households had a gender breakdown of 60% male and 40% female and the average age of the respondents was 39 years. The number of adult equivalents in each household are computed using the McClement Equivalence Scale (DEFRA, 2006). The quantity of food consumed is reported on a per-person per week basis for over 550 food item categories. These 550+ food categories are aggregated into the following major food categories:

1. Milk and milk products excluding cheese
2. Cheese
3. Carcase meat
4. Non-carcase meat and meat products
5. Fish
6. Eggs
7. Fats
8. Sugar and preserves
9. Fresh and processed potatoes
10. Fresh and processed vegetables, excluding potatoes
11. Fresh and processed fruit
12. Bread
13. Flour
14. Cakes, buns and pastries
15. Biscuits and crispbreads
16. Other cereals and cereal products
17. Beverages
18. Other food and drink
19. Soft drinks
20. Confectionery

21. Alcoholic drinks

Results

Baseline and Changed Nutritional Status

Table 2 presents the present nutritional status of dietary consumption in the UK alongside the nutritional status of the optimised diets from the QP exercise.

Table 2: Nutritional status of current and optimised UK diets

Dietary Factor	Current UK diets (Family Food 2019-20)	Optimised diets
	(as percent of energy intake)	
Total fats	38.3%	30%
Saturated fats	14.3%	10%
Polyunsaturated fats	6.59%	6%
Monounsaturated fats	15.21%	12.02%
Protein	13.6%	14.93
Free Sugars (Non-milk extrinsic sugars)	13.06%	5%
	(Daily consumption)	
Fruit and vegetables	318 grams	410 grams
Sodium	2.4 grams	2.4 grams
Dietary fibre (Southgate)	17.25 grams	30 grams

The current dietary consumption patterns in the UK involve a substantial excess consumption of total fats, saturated fats and non-milk extrinsic sugars in relation to the dietary guidelines and deficient consumption of fruit and vegetables and dietary fibre. It is these deviations from the dietary guidelines that drive the change in the consumption of food products in the optimised diets.

Figure-1 and Table -3 summarise the change in the per capita consumption of aggregated categories of food products necessary for conformity to the dietary guidelines. The QP model is applied to the mean per capita consumption of different food products from the Family Food data for 2019-20 for foods purchased for consumption at home.

Figure 1: Percentage change in per capita consumption of food products for conformity to the dietary guidelines.
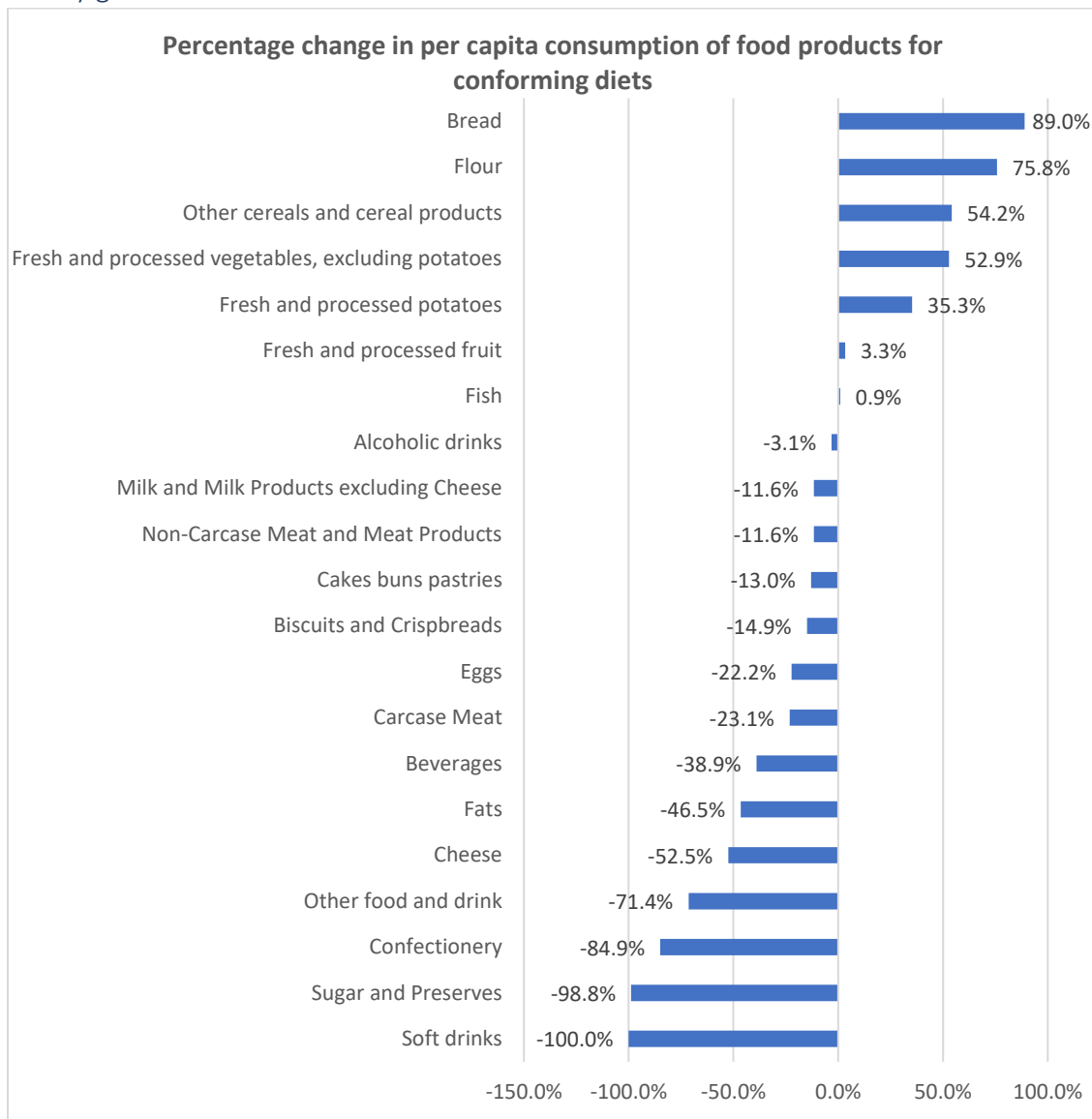

Percentage change in per capita consumption of food products for conforming diets

Food product	Percentage change
Bread	89.0%
Flour	75.8%
Other cereals and cereal products	54.2%
Fresh and processed vegetables, excluding potatoes	52.9%
Fresh and processed potatoes	35.3%
Fresh and processed fruit	3.3%
Fish	0.9%
Alcoholic drinks	-3.1%
Milk and Milk Products excluding Cheese	-11.6%
Non-Carcase Meat and Meat Products	-11.6%
Cakes buns pastries	-13.0%
Biscuits and Crispbreads	-14.9%
Eggs	-22.2%
Carcase Meat	-23.1%
Beverages	-38.9%
Fats	-46.5%
Cheese	-52.5%
Other food and drink	-71.4%
Confectionery	-84.9%
Sugar and Preserves	-98.8%
Soft drinks	-100.0%

Table 3: Change in consumption of food products for conformity to dietary guidelines

Product category	Units	Current per capita per day consumption (Family Food 2019-20)	Per capita consumption per day in diet conforming to dietary guidelines	Percentage change
Milk and Milk Products excluding Cheese	gms	249.37	220.48	-11.6%
Cheese	gms	18.47	8.78	-52.5%
Carcase Meat	gms	24.26	18.66	-23.1%
Non-Carcase Meat and Meat Products	gms	111.33	98.43	-11.6%
Fish	gms	21.15	21.34	0.9%
Eggs	no.	0.32	0.25	-22.2%
Fats	gms	22.59	12.08	-46.5%
Sugar and Preserves	gms	12.43	0.15	-98.8%
Fresh and processed potatoes	gms	79.95	107.00	33.8%
Fresh and processed vegetables, excluding potatoes	gms	163.88	250.64	52.9%
Fresh and processed fruit	gms	154.24	159.36	3.3%
Bread	gms	74.88	141.54	89.0%
Flour	gms	7.67	13.48	75.8%
Cakes buns pastries	gms	23.33	20.30	-13.0%
Biscuits and Crispbreads	gms	24.65	20.97	-14.9%
Other cereals and cereal products	gms	86.67	133.64	54.2%
Beverages	ml	7.93	4.85	-38.9%
Other food and drink	gms	133.38	38.14	-71.4%
Soft drinks	ml	236.86	0.00	-100.0%
Confectionery	gms	20.54	3.10	-84.9%
Alcoholic drinks	ml	103.97	100.74	-3.1%

It should be noted that the percentage changes in the 21 major food product categories described above are aggregated from the change in consumption of over 255 food product sub-categories that comprise the major food product categories. The overall percentage change in consumption in any major food product category can reflect offsetting changes in the consumption of different sub-categories, i.e., within a given major food product category, the consumption of some categories may increase, while the consumption of other categories may decrease. The details of changes in the per capita consumption of individual sub categories is provided in a separate spreadsheet. The important features of the changes in consumption of different food product categories to transition to diets conforming to dietary guidelines are summarised below:

(a) The reduction in the consumption of milk and milk products reflects different adjustment patterns for individual products. The overall reduction of 11.6% includes a very large reduction in the consumption of cream (60%) and a 15-30% reduction in the consumption of different types of milk. This is offset by an increase in the consumption of skimmed milk (18%) and instant dried milk (26%).

(b) The overall decrease in cheese consumption of 52.5% is derived from a 14-60% decrease in the consumption of different types of cheese.

(c) A reduction in the consumption of carcase meat (mainly beef, mutton and pork) of 23% is required for adherence to dietary guidelines. This includes a reduction of 21% in beef consumption, 40% in mutton and an 15% decrease in pork consumption. The only sub-category that shows a an increase is "All other beef and veal" (59%) but this category accounts for a negligible percentage of carcase meat consumption. Non-carcase meat and meat products, which include poultry, offal, processed and cooked and takeaway meat products undergoes a smaller reduction of 11.6%. However, the adjustment in this category includes an increase in the consumption of certain products such as liver, turkey, some meat based ready meals and takeaway meats. The reduction in meat consumption for adherence to dietary guidelines is probably much smaller than what would be advocated from an environmental perspective.

(d) The dietary adjustment calls for a 22% decrease in the consumption of eggs and a 1% increase in the consumption of fish. The small overall increase in fish consumption is the result of offsetting changes in the consumption of different types of fish, with a 17-24% increase in the consumption of white fish and a 30% increase in some takeaway fish based meals and reduction of 12-27% in herring, salmon and dried, smoked or salted fish.

(e) The excess of consumption of sugar in current diets drives the elimination of soft drinks (98% reduction) in the diet, very large reductions in sugar and preserves (98%) and confectionery (85%) and smaller reductions in cakes, buns and pastries (13%), biscuits and crispbreads (15%).

(f) As expected, adherence to dietary guidelines calls for a substantial increase in the overall consumption of vegetables (53%) which includes a 100-200% increase in the consumption of some vegetables alongside reductions in the consumption of certain canned vegetables, vegetable takeaway products and juices, cucumbers, tomatoes and in marrow, courgettes, aubergines and pumpkins. The overall increase in fresh and processed fruit is only 3.3% - this is derived from large increases in the consumption of certain fruits offset by reductions in the consumption of fruits with high sugar content such as citrus fruits, grapes and pineapples, fruit juices and tinned and bottled fruit.

(g) Other products where there are large increases are bread (89%), flour (76%) and other cereals and cereal products (54%). The increase in bread covers all categories of bread, including white bread, wholemeal bread and sandwiches and takeaway breads, although the largest increase is for wholemeal and granary bread. The results for bread and flour are somewhat unexpected and the reasons for the large increase in these categories needs to be explored further. The increase in other cereals and cereal products is the result of increases in items like breakfast cereals, pasta and cereal based snacks, offset by reductions in puddings, cakes pastries.

(h) The consumption of beverages shows a reduction of 39% possibly on account of the added sugar content in the beverages. Alcoholic drinks were constrained not to increase and show a small reduction of 3.1%. Alcoholic drinks contribute to the calorie intake but make a negligible contribution to the consumption of macronutrients such as fats, sugars and proteins.

Notes:

1. The percentage changes in the consumption of different food products to achieve conformity to dietary guidelines are quite similar to the above if we take the data from Family Food 2020-21 or 2021-22 as the baseline.

2. Family Food data can also be analysed by socio-demographic characteristics – by income quintile, region, age/education of household head, ethnic origin etc. However, only the changes in consumption of food products at the aggregate level may be relevant for the FAPRI-UK model scenarios.

3. The QP results are sensitive to the multiple used in the constraint in equation 10 above, i.e., the consumption of individual products should not increase by more than 300%. As noted above, this constraint appears to be necessary to preserve dietary diversity in the changed diets. Given that our objective function seeks to minimise changes from the existing diets, the multiple of 3 used in the above estimations appears to be reasonable.

4. It remains to be considered how the percentage changes in the consumption of different food products in the above estimations can be translated into percentage changes at the level of commodities in the FAPRI-UK model. In the above estimations, percentage changes at the major food category level have been calculated by aggregating the weight (gms or ml) of the individual food products within that major food category.

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