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COST AND AFFORDABILITY OF PREPARING A BASIC MEAL AROUND THE WORLD

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ABSTRACT

About 690 million people are chronically undernourished, roughly 2 billion experience food insecurity, and around 3 billion people cannot afford enough of the diverse foods needed for a healthy diet, even as all countries of the world have a rising burden on diet-related disease from consumption of unhealthy foods. This research brief aims to extend previous work on diet cost and affordability such as the SOFI 2020 report to address the hidden costs of meal preparation inside the home, after foods are grown or purchased by each household. We start with market prices for the most affordable items with which to prepare a basic meal in 168 countries around the world, then address

the cost of switching between pulses and animal protein foods that people may choose, and the costs of switching between raw ingredients and precooked items such as canned beans, tomatoes or fish.

To quantify the cost of meal preparation, we focus on fuel use for rural households in East Africa, and consider the cost of the charcoal, gas or electricity required for cooking the least-cost dry pulses in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. This analysis is just a first step towards measuring the cost and affordability of meal preparation, which depends on many factors such as a household's kitchen equipment, water and fuel sources,

distance to markets, demographic composition and cost of time. Our work on the hidden costs of meal preparation goes beyond market prices of food itself to consider other barriers to consumption of a healthy diet by each household, and complements true cost accounting that takes account of environmental or social externalities from production and distribution of food, as well as the health externalities involved in food consumption.

The data shown here reveal that even just the raw ingredients for a basic plate are often unaffordable for the poorest, and the added cost of time and fuel can make such meals prohibitively expensive. Results suggest two main avenues for policy action. First, governments now can and should use the information on the least costly way to meet dietary standards to inform poverty lines and provide targeted assistance to ensure that citizens can acquire safe and nutritious items in sufficient quantities for an active and healthy life, using local-appropriate safety nets. Second, food policies should recognize the hidden costs of meal preparation that often put healthier, more sustainable diets out of reach.

Overcoming the hidden barriers to preparation of healthy meals will require support for helpful forms of food processing such as cooking and canning beans, fish, tomatoes or other foods that preserve or even enhance nutritional values, while simultaneously taking action to limit potentially harmful forms of ultra-processing such as excessive levels of added sugar, salt or trans fat and other factors associated with diet-related disease. Actions that support helpful forms of food processing while limiting harmful processing could help households improve diet quality, while also reducing the time burden, respiratory diseases and climate-change consequences of using wood or

charcoal for cooking, as well as other inefficient and inequitable aspects of meal preparation. Taken together, food-based safety nets and improvements in the food environment can make healthy diets affordable for all people at all times, to help every country reach global development goals.

1. INTRODUCTION

A nutritious diet is essential for an active and healthy life but is unaffordable for about 3 billion people, almost 40% of the world's population, who have insufficient income to afford enough of even the least-cost foods needed for a healthy diet (FAO, IFAD, UNICEF, WFP and WHO, 2020). The unaffordability of nutritious foods prevents many people from consuming a healthy diet, but market prices for raw agricultural produce are not the only barrier to improved diet quality. To form an inclusive and sustainable food system for all, policies and programs should address other obstacles such as:

- the time burden and fuel use needed to cook safe and nutritious meals at home, especially in households with poor kitchen facilities and other constraints,
- high prices of healthy items that would be pre-cooked and prepared in ways that preserve and enhance nutritional value while reducing the time and fuel required for meal preparation, and
- rapidly growing availability of ultra-processed foods whose convenience, taste and brand reputation meet peoples' immediate needs, but are linked to diet-related disease later in life.

This brief extends earlier work on market prices such as Bai et al. (2021b), Herforth et al. (2020), Hirvonen et al. (2020), Masters et al. (2018) and others to

consider the hidden costs of meal preparation, including home-cooked versus pre-cooked versions of similar foods as well as the relative costs of plant- and animal-sourced ingredients.

Focusing on the hidden costs of meal preparation that affect food choice complements other work on true cost accounting, including research on external harms from unhealthy or unsustainable foods and cooking methods as well as the external benefits of healthier or more sustainable practices, as described in a companion Food Systems Summit Brief from the Scientific Group's true cost working group. In this research partner's brief we use the data and methods developed for SOFI 2020 and related work from a larger project on Food Prices for Nutrition (2021).




To illustrate how meal preparation costs could influence food choice we use the "Basic Plate" approach developed by the World Food Programme (WFP 2017), identifying the most affordable ingredients for a typical meal that might be consumed in any country of the world. The baseline meal consists of a starchy staple made from 75g of a dry cereal grain or equivalent, accompanied by a bean or lentil stew made from 57.25g of dry pulses, cooked with onions (16.25g) and tomatoes (55 g) in a vegetable oil (28.13g). Such a meal would contain about one-third of an adult's daily energy requirement, and is not itself a healthy diet. To meet all needs a person's overall diet would require greater diversity

including additional vegetables and fruits, but those complements to the basic meal are often more location-specific as shown in our previous work such as Herforth et al. (2020).

Measuring the market prices and hidden costs of preparing a single basic plate allows us to begin addressing the diverse costs of meal preparation, accounting for differences across countries and among households in time use, cooking fuel and other aspects of nutrient preservation and delivery. Using global data, we compare the most affordable basic plate with pulses to alternative meals that use animal-sourced proteins (red meat, poultry, or fish), and alternative meals that would reduce the energy and time required for meal preparation by using pre-cooked versions of various foods such as bread or canned fish, beans, and tomatoes.

The composition of each basic plate used for this study is shown in Table 1 below. To begin, we identify the most affordable items from which to prepare these basic plates in 168 countries around the world, using nationally-representative retail prices for calendar year 2017 provided by government statistical organizations through the World Bank's International Comparison Program (ICP 2021). Details on the food items are shown in annex Tables A1 and A2, as the least-cost items in each country drawn from the candidate foods in each category listed in Tables A3 and A4.

Table 1. Basic and alternative versions of the WFP plate of food

Basic plate	Animal-sourced proteins	Pre-cooked or prepared foods
		
<p>Pulses & beans Plant oils Onions Tomatoes Starchy staples</p>	<p>Replace pulses with animal-sourced proteins, including red meat, poultry, and fish.</p>	<p>Replace raw with pre-cooked foods such as canned beans instead of dry pulses, canned tomatoes or fish instead of fresh or dried and salted fish, and bread instead of other starchy staples.</p>

Note: Each basic plate allows substitution to the most affordable item available in that country for the starchy staple (75g of a dry cereal grain or equivalent, totaling 270kcal) with a stew made from pulses (57.25g of a dry bean or equivalent, totaling 191kcal), tomatoes (55g = 10kcal) and onion (16.25g = 6.5kcal) in vegetable oil (28.1g = 242kcal). Available foods and their prices are from ICP (2021), matched to food composition using methods detailed in Food Prices for Nutrition (2021).

To assess affordability, we divided the cost of each plate by average total spending per person in that country, as measured by Gross National Income (GNI) per capita in real purchasing power parity (PPP) terms. All prices and costs reported here are in PPP dollars for 2017, so they can be directly compared to the international poverty line of \$1.90/day and other benchmarks expressed in real PPP dollars. As shown in Table 2, we find that the average cost of the most affordable items

with which to prepare the basic plate is \$0.71, excluding costs of meal preparation. Choosing pre-cooked foods such as canned beans, fish or tomatoes and bread more than doubles that cost to \$1.77 per day. Substituting animal-source proteins also raises the cost substantially to \$1.03 for a plate with red meat, \$1.07 with poultry, and \$1.30 with fish. For the plates with animal-sourced proteins, however, the pre-cooked or more convenient foods are actually less costly.

Table 2. Global average cost per day of the WFP basic plate and alternatives (2017 USD)

	Basic plate	With animal protein		
	Pulses	Red meat	Poultry	Fish
With most affordable items	0.71	1.03	1.07	1.30
With precooked, packaged items	1.77	1.03	1.16	1.32
With raw or whole items	0.73	1.44	1.21	2.64

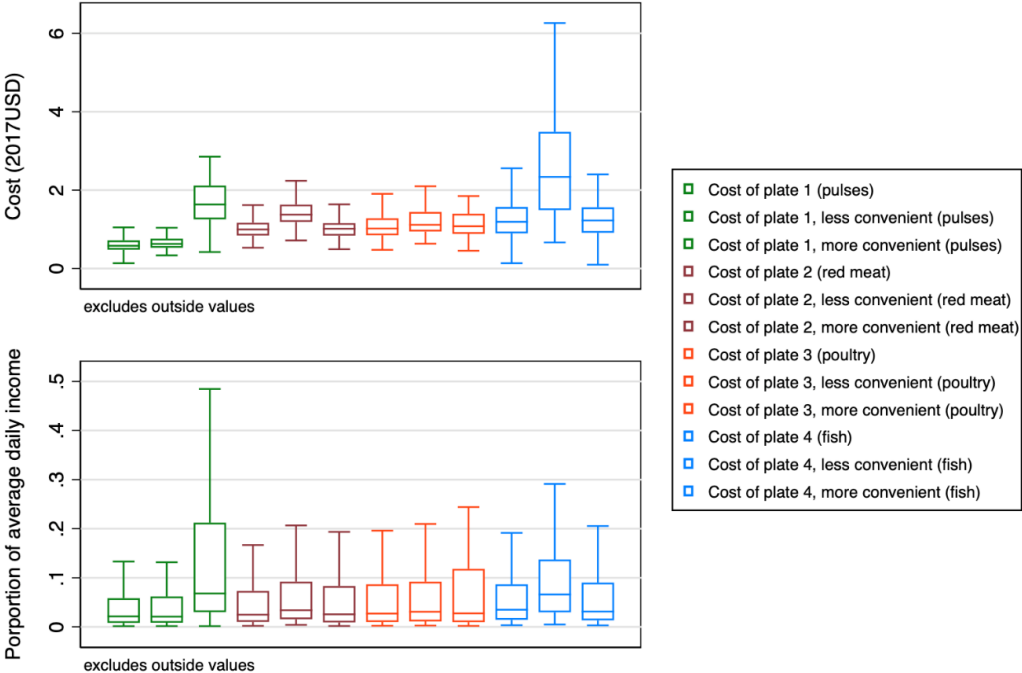
Note: Data shown are the mean over 168 countries for which all required data are available.

The cost of each of the basic and alternative plates generally takes a small portion of each country's total national average income, but a large fraction of the international poverty line at \$1.90/day and often exceeds the daily income of resource-poor households. In one-fourth of countries where these foods are least affordable, the basic plate costs about 6 % or more of average daily income, meaning the value of all goods and services in that society. That cost rises to 20% of all goods and services if the meal is made with pre-cooked items and 10% of all goods and services if the plate includes red meat, poultry, or fish. The plate is also slightly more expensive when using fresh fish instead of pre-cooked tinned fish (Figure 1).

When considering the cost per meal shown above, it is important to note that

this basic plate meets about one-third of daily caloric needs in a safe and acceptable manner, but other foods would be needed to meet nutritional needs for an active and healthy life. For example, comparing this basic meal to an entire day's diet that would meet requirements specified in a variety of national food based dietary guidelines (FBDGs), the meal contains about 80% of what would be an entire day's recommended intake of vegetable oil (28 out of 35 grams in a typical FBDG), but only 23% of the day's protein-rich foods (57 of 250 grams), and 24% of the day's vegetables (71 of 300 grams), as well as none of the recommended fruit or dairy and other foods. Analysis of the overall cost of a healthy diet is outside the scope of this brief and is addressed in earlier work such as Herforth et al. (2020).

Figure 1. Global range of costs of the WFP basic plate and alternatives (2017 USD)



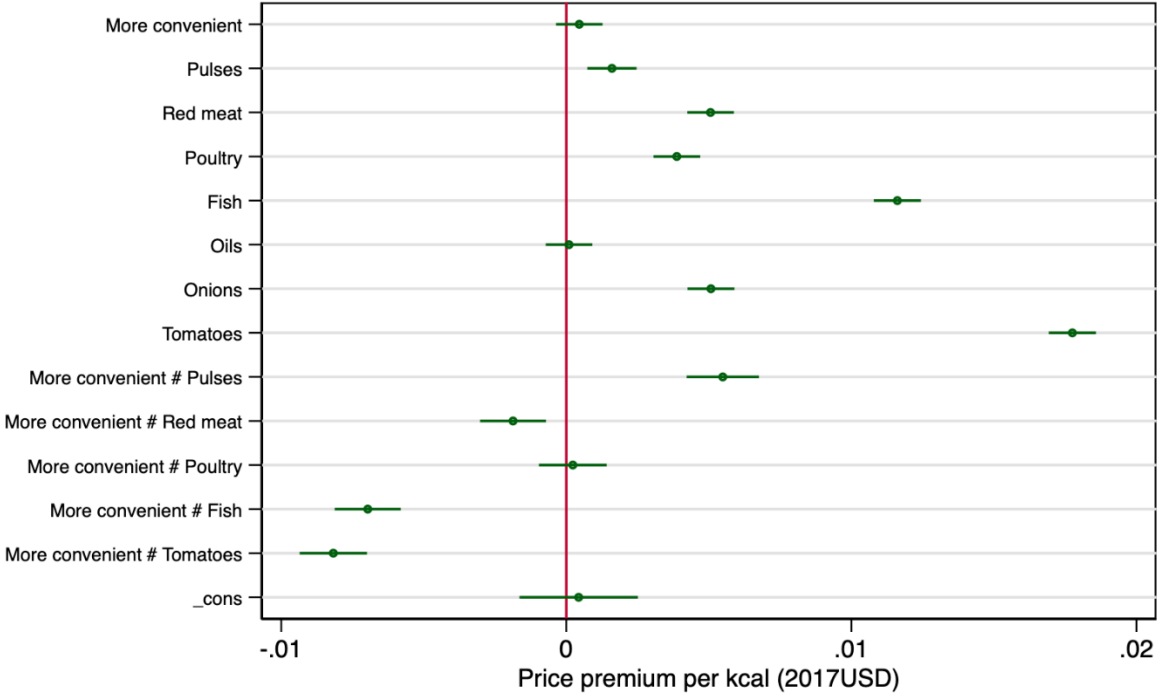
Note: Data shown are the range of meal costs across 168 countries with available data. For each type of meal, the box shows median meal costs and its interquartile range from the 25th to 75th percentile (at the middle, top and bottom of each box), and whiskers show the outer range of 1.5 times that interquartile range. Outliers beyond the range are omitted for visual clarity.

2. PRICE PREMIUMS FOR THE MOST AFFORDABLE ITEMS IN EACH CATEGORY

To address food choice within the overall diet, we examine the added cost of pre-cooked items and alternative proteins at the item level. Pulses are only slightly more costly than starchy staples per calorie (a difference of about \$0.001/kcal, or \$0.10 per 100 kcal). Red meat and poultry are about \$0.50 per 100 kcal more expensive than starchy staples, as are onions while including tomatoes adds roughly \$1.80 per 100 kcal. All of those premiums are for the raw form of the product.

Using pre-cooked canned beans instead of dry beans adds as much cost as switching to red meat or poultry, which have about the same cost in whole raw form versus a lightly processed and packaged version (for example, ground beef is not systematically more or less expensive than beef for stew). On the other hand, fish and tomatoes are much less expensive when purchased in pre-cooked and canned form, making pre-cooked tinned fish about the same cost per 100kcal as uncooked raw red meat or poultry.

Figure 2. Average premium required to obtain the least-cost item with each attribute



Data shown are the global average premium for the most affordable food item in each food category compared to the most affordable carbohydrate, by OLS regression with fixed effects for each of 168 countries in 2017 (n=2,194 food items)

3. THE HIDDEN COST OF HOME COOKING: TIME AND FUEL USE

Our analysis of ingredient prices reveals that preparing a basic plate with pre-cooked pulses such as canned beans is much more expensive than the plate with dried pulses, while the same with canned fish is less expensive than with fresh fish. Moreover, preparing the plate with pre-cooked pulses raises its costs beyond using the most affordable fish as the protein component. Given the high preparation time and cost of cooking for meals using dried pulses, and the high environmental impacts of animal sourced protein production, the high cost of helpful, healthy processing could be an important obstacle to inclusive and sustainable dietary transformation.

Data on the time and resources required for food acquisition and meal

preparation across countries are not yet available. Still, we can begin to illustrate differences in the cost of meal preparation by focusing on energy use for cooking beans in East Africa, extending our previous research on food price variation in this region (Bai et al. 2020). We focus the portion of the pulse in the basic plate because preparing and cooking dry beans for a meal requires considerable time and fuel. Home-cooked beans have similar nutritional composition to pre-cooked tinned beans available in retail food outlets. We cannot account for all factors that go into meal preparation but can use this example to address differences in fuel cost as one influence on the cost and affordability of each food.

To compare the cost of cooking beans or other pulses, we focus on the fuel needed to cook dry beans in East Africa, as estimated by MECS (2019) which is a

simplified version of more detailed analyses such as Nerini, Ray and Boulkaid (2017). To compute fuel cost per serving, we consider the quantity of fuel to cook 500g of dry beans (enough for 8.7 servings in the basic plate) which is estimated by MECS (2019) to require 0.675 kg of charcoal, or 0.2 kg of gas (LPG), or 1.5 kWh of electricity when using the most common, conventional types of stoves in this region. On a per-serving basis, that amounts to 77g of charcoal, 23g of LPG gas, or 0.17 kWh. We applied this estimate to six East African countries that are likely to use similar food preparation technologies and techniques – Burundi, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda. The mix of fuels and cooking methods actually used vary widely, with the fraction of households that have access to electricity in 2017 ranging from a majority of households in Kenya (63.6) to a smaller proportion in Ethiopia (44.3), Rwanda (34.1), Tanzania (32.7), Uganda (31.8) and Burundi (9.3), as reported in World Bank (2021).

For each country we compare the fuel costs for cooking to the cost of the food itself. In each case the least-cost pulse is spotted beans, whose nationally-representative cost per 57g serving in 2017 USD ranged from 8.6 cents in Rwanda to 17.2 cents in Ethiopia. We then compare that to the cost of each type of fuel. The results shown in Figure 3 reveal no consistent ranking in fuel costs, but in two cases (Rwanda electricity and Uganda gas), the cost of fuel exceeds the cost of the beans themselves.

Our analysis so far focuses only on meal costs at national average market prices for ingredients and fuel. How each food is actually cooked varies with household circumstances, including availability of kitchen equipment, local variation in costs at each time and place,

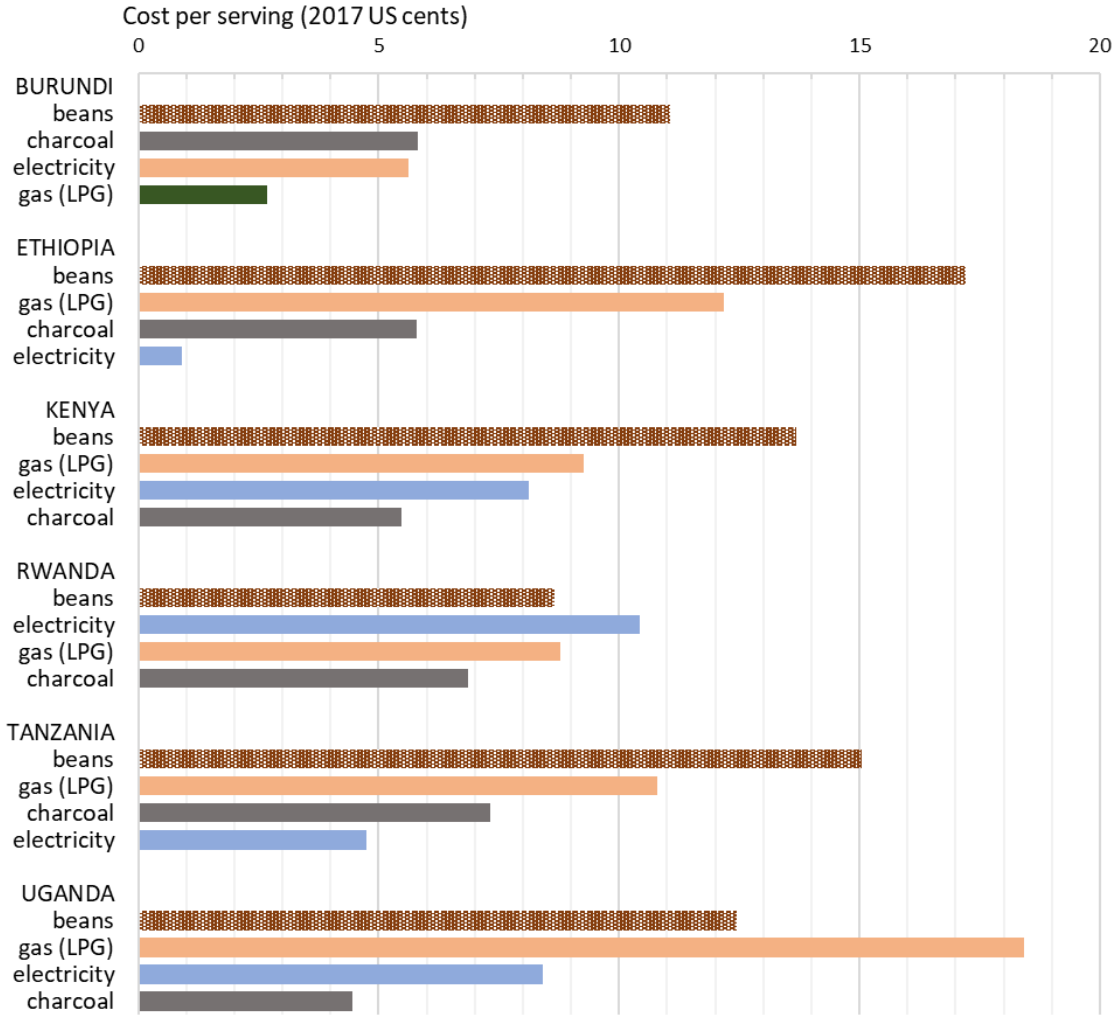
and cultural or demographic factors that influence each household's division of labor related to meal preparation. Home cooking may also impose large health costs from indoor smoke, and how foods are prepared and served or stored can also have important consequences for foodborne illness and food waste as well as externalities associated with deforestation and emissions. Reducing the inequities and total costs associated with inefficient cooking might sometimes be possible with innovations in food processing that would preserve and even enhance the nutritional value of foods. For the basic meal with pulses in East Africa, however, using canned beans would cost roughly 3-4 times the cost of dry beans plus the required cooking fuel, at a price per serving that ranges from \$1.25 in Kenya to \$1.37 in Tanzania, \$1.42 in Burundi and Ethiopia, \$1.55 in Uganda and \$1.66 in Rwanda.

This case study is just one small step towards including the costs of meal preparation in future work on the cost and affordability of a healthy diet. In so doing, we build on an long and diverse literature on meal preparation as a determinant of diet quality and health outcomes, and studies of cooking fuel as a driver of household health and environmental harms. Regarding diet quality in low- and middle-income countries, the recent literature was pioneered by Kennedy and Reardon (1994) on how urbanization in Kenya and Burkina Faso led to shifts from coarse to refined grains, and includes many papers on how time use in rural households relates to nutrition as reviewed by Johnston et al. (2018) plus later contributions on time use including Seymour et al. (2019, 2020) and Vemireddy and Pingali (2021). Similar issues arise in studies of time use and diet quality for higher-income settings, such as Raschke (2012), Smith, Ng and Popkin (2013), Yang, Davis and Muth (2015), and Carpio et al.

(2020) in the U.S., or Mackay et al (2017) in New Zealand. Regarding the health effects of indoor smoke and environment consequences of wood and charcoal, several studies address the prevalence of

each fuel type and the drivers of change (Heltberg 2004, Bonjour et al 2013, Shupler et al. 2019), in some cases tracing their effects to time management and fuel choice (Anderman et al. 2015).

Figure 3. Cost per serving of the most affordable pulse and fuel for a plate of beans in East Africa



Note: Data shown are the nationally-representative retail price of 57.25g for the most affordable kind of pulse, which in each country is spotted beans, compared to the cost of fuel using quantities from MECS (2019) and prices from ICP (2021) as detailed in the text.

This research brief links meal preparation to the cost and affordability of healthier diets, focusing on the relative cost of raw ingredients as opposed to precooked and packaged foods, and comparing the ingredient costs to fuel

costs for beans in East Africa. To address how the costs of meal preparation and the increasing availability of processed foods affect food choice, it will be especially important to identify forms of food processing that preserve and enhance

nutritional values, as opposed to the growing health risks associated with existing types of ultra-processed food that have been shown in observational studies reviewed by Pagliai et al. (2021) and Lane et al. (2021) as well as one randomized control trial (Hall et al. 2020). The need for policies and programs to distinguish between healthier and less healthy packaged foods is important for the food safety agenda (Jaffee et al. 2020), and could help ensure that food system transformations bring healthy and nutritious diets within reach for all people at all times, in every country of the world.

4. OPPORTUNITIES FOR ACTION

A basic plate of healthy food is unaffordable for many of the world's most resource-poor households, due not only to the high cost of growing or purchasing raw ingredients, but also the high cost of meal preparation within the home. Government policies and programs could build on past work such as the SOFI 2020 report, CFS (2021) and other initiatives to ensure food security for all through two specific kinds of action suggested by our findings:

- (1) revised poverty lines and safety nets** to ensure that all people at all times can acquire the foods needed for a healthy diet, using locally-appropriate criteria for targeting and forms of assistance including cash transfers, vouchers and in-kind assistance; and
- (2) improved cooking and processing** to reduce the health and environmental burdens of meal preparation, for example through electrification using renewable energy sources as well as support for helpful processing that preserves the nutritional value of

foods, in distinction to ultra-processing that may remove beneficial components and add attributes that are associated with illness later in life.

The first of these potential game-changers calls on governments to make healthy diets affordable for all by using the minimal cost of a healthy diet to examine food poverty thresholds and inform eligibility for nutritional safety nets that provide cash transfers, vouchers, or in-kind support to supplement a household's own income or food production. Safety nets designed around access to a healthy diet can be the foundation for social inclusion, using 21st century data analysis to target and deliver assistance in all countries of the world. Recent improvements in market monitoring and analysis of diet costs allow governments to target and deliver nutrition assistance tailored to local needs, with food-based poverty lines to guide programme design parameters suited to each population, targeting by demographic group and delivering through locally adapted instruments including cash, vouchers, and in-kind assistance. As noted by Hendriks (2018), making healthy diets affordable by tackling poverty is a necessary but not sufficient step towards food security and nutrition, which also requires improvements in the quality and price of available foods to enable behavior change for food and nutrition security of all people at all times.

The second of these game-changers addresses hidden costs in the "last mile" of food security for households to acquire foods and prepare each meal. Food acquisition and preparation often places high burdens on caregivers' time and can impose additional financial costs for cooking fuel, equipment, and transportation. Governments should support the development of infrastructure

that will reduce the burden of food acquisition and preparation, such as rural electrification, and support agri-food processing that reduces the time and fuel cost of home cooking while preserving the nutritional value of foods.

The main action step within the food system is to distinguish between helpful processing that preserves or even adds to the healthfulness of food, versus harmful ultra-processing that transforms food, removing healthful aspects of foods such as whole grains and sometimes adding health risk factors such as refined carbohydrates and sugars, sodium, and trans fats. Actively making that distinction allows support for the helpful kinds of healthy processing, often by local SMEs, while also using regulation and taxation to limit harmful forms of ultra-processing.

To guide these interventions, governments will need to continue investing in improved data collection about food prices, the externalities involved in true cost accounting, and the hidden costs of food acquisition and meal preparation within the home. Governments routinely collect nationally representative market prices for a variety of foods each month to calculate their consumer price indexes, and international agencies such as the WFP, FAO and FEWS NET also collect rural market prices to target food assistance (Bai et al. 2021a). The World Bank is expanding its global office for the ICP to focus on food prices and diet costs, in collaboration with national statistical organizations around the world (Food Prices for Nutrition, 2021).

As shown in this research brief, governments can complement this work with attention to other barriers to affordability beyond market prices, such as the time and resources required for food acquisition, meal preparation and cooking fuel. Accurately measuring these hidden costs is also helpful for true cost accounting

of externalities associated with the environmental footprint of food production, processing, and distribution, as well as the health effects of food consumption. These costs differ between different types of agricultural ingredients, and also differ among types of processing. The hidden costs of meal preparation, as well as environmental costs and health burden associated with diet-related disease call for attention not only to different kinds of farm production but also a new kind of distinction between helpful, healthy kinds of food processing in distinction to ultraprocessed foods that are increasingly important cause of diet-related disease around the world.

In summary, the data described in this research brief lead to two game-changing actions:

- (i) poverty lines and safety nets informed by the cost of a healthy diet to ensure that all people at all times can acquire the foods needed for lifelong health, using appropriate targeting and forms of assistance including cash transfers, vouchers, and in-kind assistance; and
- (ii) actions to reduce the burden of meal preparation for healthy diets, through electrification using renewable energy sources as well as support for helpful processing that preserves the nutritional value of foods, in distinction to ultra-processing that may remove beneficial components and add attributes that are associated with illness later in life.

Through these actions governments can use new kinds of data and analytical methods to meet universal needs in locally-appropriate ways, thereby ensuring food and nutrition security for all.

REFERENCES

- Anderman TL, DeFries RS, Wood SA, Remans R, Ahuja R, Ulla SE (2015). Biogas cook stoves for healthy and sustainable diets? A case study in Southern India. *Frontiers in Nutrition*. 2:28
<https://doi.org/10.3389/fnut.2015.00028>
- Bai Y, Naumova EN, Masters WA (2020). Seasonality of diet costs reveals food system performance in East Africa. *Science Advances*. 6(49):eabc2162.
<https://doi.org/10.1126/sciadv.abc2162>
- Bai Y, Costlow L, Ebel A, Laves S, Ueda Y, Volin N, Zamek M, Herforth A, Masters WA (2021). Retail food prices around the world: Systematic assessment of data from national governments and international agencies. *Food Policy*, forthcoming. Preprint at
<http://dx.doi.org/10.2139/ssrn.3802091>
- Bai Y, Alemu R, Block SA, Headey D, Masters WA (2021). Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries. *Food Policy*. 99:101983.
<https://doi.org/10.1016/j.foodpol.2020.101983>
- Bonjour S, Adair-Rohani H, Wolf J, Bruce NG, Mehta S, Prüss-Ustün A, Lahiff M, Rehfuess EA, Mishra V, Smith KR (2013). Solid fuel use for household cooking: country and regional estimates for 1980–2010. *Environmental Health Perspectives*, 121(7):784-90.
doi.org/10.1289/ehp.1205987
- Carpio CE, Kalenkoski CM, Moyeda-Carabaza AF, Murimi M (2020). The effect of time use and food cost on dietary quality. *Public Health Nutrition*. 23(18):3284-94.
<https://doi.org/10.1017/S1368980020001615>
- CFS (2021). Voluntary Guidelines on Food Systems and Nutrition. Forty-seventh Session "Making a Difference in Food Security and Nutrition", 8-11 February 2021. Committee on World Food Security, Rome.
<http://www.fao.org/3/ne982en/ne982en.pdf>
- FAO, IFAD, UNICEF, WFP and WHO (2020). The State of Food Security and Nutrition in the World 2020: Transforming food systems for affordable healthy diets. FAO, Rome.
<http://www.fao.org/publications/sofi>
- Food Prices for Nutrition (2021). Diet cost metrics for a better-fed world (project website). Tufts University, Boston.
<https://sites.tufts.edu/foodpricesfornutrition>
- GloPan (2016). Food systems and diets: facing the challenges of the 21st century. Global Panel on Agriculture and Food Systems for Nutrition, London.
www.glopan.org/reports/foresight
- Heltberg R (2004). Fuel switching: evidence from eight developing countries. *Energy Economics* 26(5):869-87.
<https://doi.org/10.1016/j.eneco.2004.04.018>
- Hendriks, SL (2018) Food policy and nutrition economics in the SDG era, *Agrekon*, 57(3-4): 167-180.
<https://doi.org/10.1080/03031853.2018.1479974>
- Herforth A, Bai Y, Venkat A, Mahrt K, Ebel A, Masters WA (2020). Cost and affordability of healthy diets across and within countries: Background paper for The State of Food Security and Nutrition in the World 2020. Agricultural Development Economics Technical Study No. 9. Food and Agriculture Organization of the UN, Rome.
www.fao.org/documents/card/en/c/cb2431en

- Hirvonen K, Bai Y, Headey D, Masters WA (2020). Affordability of the EAT–Lancet reference diet: A global analysis. *The Lancet Global Health*, 8 (1): e59-e66. [https://doi.org/10.1016/S2214-109X\(19\)30447-4](https://doi.org/10.1016/S2214-109X(19)30447-4)
- ICP (2021). The International Comparison Program. Washington, The World Bank <https://www.worldbank.org/en/programs/icp>
- Jaffee S, Henson S, Grace D, Ambrosio M, Berthe F (2020). Why food safety matters to Africa: Making the case for policy action. Chapter 10 (pages 112-29) in *Sustaining Africa's agrifood system transformation: The role of public policies*, edited by D. Resnick, X. Diao and G. Tadesse, ed. Washington, DC, and Kigali: IFPRI and AKADEMIYA2063. https://doi.org/10.2499/9780896293946_10
- Johnston D, Stevano S, Malapit HJ, Hull E, Kadiyala (2018). Time use as an explanation for the agri-nutrition disconnect: evidence from rural areas in low and middle-income countries. *Food Policy*, 76: 8-18. <https://doi.org/10.1016/j.foodpol.2017.12.011>
- Kennedy E, Reardon T. (1994). Shift to non-traditional grains in the diets of East and West Africa: role of women's opportunity cost of time. *Food Policy* 19(1):45-56. [https://doi.org/10.1016/0306-9192\(94\)90007-8](https://doi.org/10.1016/0306-9192(94)90007-8)
- Mackay S, Vandevijvere S, Xie P, Lee A, Swinburn B. (2017) Paying for convenience: Comparing the cost of takeaway meals with their healthier home-cooked counterparts in New Zealand. *Public Health Nutrition* 20(13):2269-76. <https://doi.org/10.1017/S1368980017000805>
- Masters WA, Bai Y, Herforth A, Sarpong DB, Mishili F, Kinabo J, Coates JC (2018). Measuring the affordability of nutritious diets in Africa: price indexes for diet diversity and the cost of nutrient adequacy. *American Journal of Agricultural Economics* 100(5):1285-301. <https://doi.org/10.1093/ajae/aay059>
- MECS (2019). The Kenya eCookbook: Beans and Cereals Edition. Modern Energy Cooking Services (MECS), Loughborough University. <https://mecs.org.uk/the-ecookbook>
- Nerini FF, Ray C, Boulkaid Y (2017). The cost of cooking a meal. The case of Nyeri County, Kenya. *Environmental Research Letters*, 12(6):065007. doi.org/10.1088/1748-9326/aa6fd0
- Pagliai G, Dinu M, Madarena MP, Bonaccio M, Iacoviello L, Sofi F (2021). Consumption of ultra-processed foods and health status: a systematic review and meta-analysis. *British Journal of Nutrition*. 125(3):308-18. <https://doi.org/10.1017/S0007114520002688>
- Seymour G, Masuda YJ, Williams J, Schneider K (2019). Household and child nutrition outcomes among the time and income poor in rural Bangladesh. *Global Food Security*, 20:82-92. <https://doi.org/10.1016/j.gfs.2019.01.004>
- Smith LP, Ng SW, Popkin BM (2013). Trends in US home food preparation and consumption: analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008. *Nutrition Journal*, 12(1):1-10. <https://doi.org/10.1186/1475-2891-12-45>
- Raschke C (2012). Food stamps and the time cost of food preparation. *Review of Economics of the Household*, 10(2): 259-275. <https://doi.org/10.1007/s11150-011-9128-3>

- Seymour G, Malapit H, Quisumbing A (2020). Measuring time use in developing country agriculture: Evidence from Bangladesh and Uganda. *Feminist Economics*, 26(3):169-99. <https://doi.org/10.1080/13545701.2020.1749867>
- Shupler, M., Hystad, P., Gustafson, P., Rangarajan, S., Mushtaha, M., Jayachtria, K.G., Mony, P.K., Mohan, D., Kumar, P., Lakshmi, P.V.M. and Sagar, V., 2019. Household, community, sub-national and country-level predictors of primary cooking fuel switching in nine countries from the PURE study. *Environmental Research Letters*, 14(8), 085006. <https://doi.org/10.1088/1748-9326/ab2d46>
- Vemireddy V, Pingali PL (2021). Seasonal time trade-offs and nutrition outcomes for women in agriculture: Evidence from rural India. *Food Policy*, 102074. <https://doi.org/10.1016/j.foodpol.2021.102074>
- WFP (2017). Counting the Beans: The true cost of a plate of food around the world. Rome: World Food Programme. <https://www.wfp.org/publications/2017-counting-beans-true-cost-plate-food-around-world>; <https://cdn.wfp.org/2020/plate-of-food/>
- World Bank (2021). Sustainable Energy for All (SE4ALL) database, reproduced in World Development Indicators as EG.ELC.ACCS.ZS. <https://databank.worldbank.org>.
- Yang Y, Davis GC, Muth MK (2015). Beyond the sticker price: including and excluding time in comparing food prices. *American Journal of Clinical Nutrition*, 102(1): 165-171. <https://doi.org/10.3945/ajcn.114.101444>

ANNEX

Table A1. Reference food items selected to convert food weight (g) to dietary energy (kcal)

<i>Food category</i>	<i>Reference item</i>	<i>Food name in FCT</i>	<i>FCT code</i>
Pulses	White beans, dried	Beans, white, mature seeds, raw	16049
Oils	Vegetable oil	Vegetable oil, palm kernel	4513
Onions	Fresh onions	Onions, raw	11282
Tomatoes	Fresh tomatoes, round	Tomatoes, red, ripe, raw, year-round average	11529
Starchy staples	Medium-grain rice	Rice, white, medium-grain raw, unenriched	20450

Note: FCT code numbers refer to the USDA SR28 database.

Table A2. Energy content of each item for isocaloric substitution within food categories

<i>Food category</i>	<i>Weight (g) per serving</i>	<i>Kcal per 100g</i>	<i>Kcal per serving</i>
Pulses	57.25	333	190.6
Oils	28.13	862	242.5
Onions	16.25	40	6.5
Tomatoes	55.00	18	9.9
Starchy staples	75.00	360	270.0

Note: The quantity of oil from the original WFP basic plate has been reduced by 10% to more closely approximate daily lipid needs. Substitutions within food categories are among versions of the food with different moisture content but similar nutrient density per calorie, for example switching the 270 kcal of carbohydrate-rich starchy staples from dry raw rice grains to potatoes, or the 190.6 kcal of dry beans into 190.6 kcal of pre-cooked canned beans, or switching the 9.9 kcal of whole tomatoes with 9.9 kcal of concentrated tomato paste. Different items in the oils and onions categories are all roughly similar in weight per kcal, so either unit of measure would yield the same result.

Table A3. Macronutrient adequacy of the basic plate

<i>Source</i>	<i>Protein</i>	<i>Lipids</i>	<i>Carbohydrates</i>
Pulses	13.37	0.49	34.50
Oils	0.00	28.13	0.00
Onions	0.18	0.03	1.52
Tomatoes	0.48	0.11	2.14
Rice	4.96	0.44	59.51
Total	18.99	29.19	97.67
Total (kcal)	76	263	391
Percent of kilocalories	10.4%	36.0%	53.6%
Acceptable range	10-35%	20-35%	45-65%

Note: Data shown are grams of each macronutrient from each food and in total for the basic meal. The bottom row shows the Acceptable Macronutrient Distribution Range (AMDR) as specified by the Dietary Reference Intakes of the U.S. Institute of Medicine (2005). Composition of each food is based on the USDA National Database for Standard Reference, Release 28 (SR-28) and the reference food items listed in Table A1.

Table A4. Items ever selected for the basic plate and its variants, by food category (n=152)

<i>Food</i>	<i>Raw (more work required)</i>	<i>Transformed (less time required)</i>
Starchy staples	Long-grain rice, not parboiled, WKB	Short pasta, BL
	Fresh sweet potatoes	Baguette, BNR
	Wheat flour, not self-rising, BL	Bread, white, loaf, BNR
	Brown Flour	Lebanese Bread
	Long-grain rice, parboiled, WKB	Spaghetti, WKB
	Maize grains, White	Egg noodles, WKB
	Maize, BL	Samoon Bread
	Wheat	Instant noodles, any flavor, WKB
	Medium-grain rice, BNR	Dried noodles, WKB
	Broken rice, 25%, BNR	Vermicelli, BL
	Sticky rice, WKB	Roll, BNR
	Short-grain rice, BNR	Bread, whole wheat, loaf, BNR
	Long-grained rice-25 to 50 KG,BNR	Round bread
	White rice #3, BNR	Bread, white, sliced, WKB
	Wheat flour, loose, BNR	Spaghetti, BL
	Corn (maize) flour, white, WKB	Short pasta, WKB
	Maize Flour, Yellow	Lasagne (sheets)
	Wholemeal flour, Atta, BL	Sliced brown bread (AFR)
	Oats, rolled, WKB	Couscous, BNR
	White rice #1, BNR	Sliced brown bread (WAS)
White rice #10, Prepacked, BL	Spaghetti, BARILLA	
Wheat semolina (suji), WKB	Bread unpacked	
Plantains, Fresh Green		
Long grain rice, family pack, WKB		
Pulses	Spotted beans	Green peas, tinned, WKB
	Dried peas, WKB (CIS)	Hommus
	Peas (AFR)	White beans in tomato sauce, tinned, HEINZ
	Dhal, Khesari, BL	
	Peas (WAS)	
	Green/mung beans, dried, BL	
	Dhal, Split Peas, BL	
	Dried Broad Beans	
	Moong dahl, loose, BL	
	Dhal, Musur, BL	
White beans, dried, BL	Canned black beans	
Onions	Fresh onions	--
Tomatoes	Fresh tomatoes, round	Tomato paste, WKB Tomato paste (Large), WKB Chopped tomatoes, BL
Oils	Soybean oil, WKB	--
	Palm oil unrefined, BL	--
	Peanut oil, WKB	--
	Vegetable oil, WKB	--
	Palm oil, WKB	--
	Olive oil, extra virgin, WKB	--
	Sunflower oil, WKB	--
	Corn oil, WKB	--
Cottonseed oil (CIS)	--	

Table A4 (continued)

<i>Food</i>	<i>Raw (more work required)</i>	<i>Packaged (less time required)</i>
Fish	Squid Fresh Small Sardines Carp Tuna steaks Rainbow-Trout (<i>Salmo gairdneri</i>) Red snapper Mackerel, un-cleaned Tilapia Sea bass Red Snapper (AFR) Cod (<i>gadus morhua</i>) Tuna steak Shrimps, whole, fresh Small fresh fish Catfish Fissikh Black pomfret Tuna Sunflower oil, BL	Mackerel fillet, tinned, in tomato sauce, WKB Dried sardines, BNR Sardines, tinned, with skin, in vegetable oil, WKB Salty herring (CIS) Tuna flakes, tinned, WKB Dried small fish, BNR Mackerel fillet, tinned, in vegetable oil, WKB Dried Machoiron, BNR Dried shrimps, BNR Fishball, BNR Salted and semi-dried fish, BL Mackerel in vegetable oil, WKB Sardines in tomato sauce, WKB Smoked shrimps/prawns, BNR
Poultry	Chicken, whole, fresh Chicken legs Chicken, live Whole duck, fresh Chicken breast, with skin and bones Native house chicken, fresh Chicken wings (WAS) Chicken, Traditionally bred, live Chicken, non-specific cuts, fresh	Chicken, whole, frozen Chicken burger Chicken, non-specific cuts, frozen Canned chicken Breakfast sausage, chicken, BNR
Red meat	Beef, center brisket Beef liver, BNR Pork, loin chop Veal breast, with bones Pork, belly (C) Beef, rump steak Sirloin steak Lamb, whole leg Beef, with bones Pork, shoulder Pork, ribs Pork liver, BNR Mutton, mixed cut Mutton Tripes Pork thigh, with bones Pork, fillet Beef without bones Mutton chop	Sausage Sausages, Whole/Frankfurter Beef, minced BEEF SAUSAGE Salami, sold loose Pork ham, pressed, WKB Bacon, smoked, WKB Luncheon Meat Canned beef, chunks, WKB Sliced ham, pork, WKB Beef Merguez (spiced) Burger

Table A5. Candidate food items whose prices and availability are reported in ICP 2017

<i>Food</i>	<i>Raw (more work required)</i>	<i>Transformed (less work required)</i>	
Pulses	Dhal, Khesari, BL	Canned black beans	
	Dhal, Musur, BL	Foul Medammas, canned	
	Dhal, Split Peas, BL	Frozen peas, small/fine, WKB	
	Dried Broad Beans	Green peas, tinned, WKB	
	Dried peas, WKB (CIS)	Hommus	
	Green beans (Pulses)	White beans in tomato sauce, tinned, HEINZ	
	Green/mung beans, dried, BL		
	Moong dahl, loose, BL		
	Peas (AFR)		
	Peas (WAS)		
	Spotted beans		
	White beans, dried, BL		
	Red meat	Beef liver, BNR	Beef sausage
		Beef without bones	Bacon, smoked, WKB
Beef, Silverside (F2a)		Beef Merguez (spiced)	
Beef, Sirloin steak (H1)		Beef, cubes for stew or curry	
Beef, center brisket		Beef, fillet, frozen, tenderloin	
Beef, center Brisket, with Bones (B2)		Beef, minced	
Beef, fillet, tenderloin		Burger	
Beef, rump steak		Canned beef, chunks, WKB	
Beef, with bones		Corned beef, WKB	
Beef, without bones, non-specific cut		Ham, air dried, sold loose	
Buffalo, without bones, non-specific cut		Ham, from the thigh, cooked and smoked, sold loose	
Goat leg		Luncheon Meat	
Goat, mixed cut, with bones		Pork ham, pressed, WKB	
Lamb Liver		Pork, schnitzel/escalope (A)	
Lamb, chops		Salami, WKB	
Lamb, hindLeg (hindquarters A)		Salami, sold loose	
Lamb, whole leg		Sausage	
Live Goat		Sausage, Frankfurter/Wiener type, artificial skin, WKB	
Live Sheep		Sausage, fresh and raw, sold loose	
Mutton Tripes		Sausages, Whole/Frankfurter	
Mutton chop		Sliced ham, pork, WKB	
Mutton chops		Veal, schnitzel/escalope (A5)	
Mutton, mixed cut			
Mutton/goat liver, BNR			
Pork liver, BNR			
Pork loin, without bones			
Pork thigh, with bones			
Pork, belly (C)			
Pork, collar (B1)			
Pork, fillet			
Pork, joint piece for roasting (B2)			
Pork, loin chop			
Pork, ribs			
Pork, shoulder			
Pork, with bones, non-specific cut			
Pork, without bones, non-specific cut			
Round steak			
Sirloin steak			
Veal breast, with bones			
Veal chops			
Veal, loin (B2)			
Veal, with bones			

Table A5 (continued)

<i>Food</i>	<i>Raw (more work required)</i>	<i>Transformed (less work required)</i>
Poultry	Chicken breast, with skin or bones	Breakfast sausage, chicken, BNR
	Chicken breast, without skin or bones	Canned chicken
	Chicken legs	Chicken breast, fillets, shreds or dices
	Chicken wings (ASI)	Chicken burger
	Chicken wings (WAS)	Chicken nuggets/dippers, frozen, WKB
	Chicken, Traditionally bred, live	Chicken soup
	Chicken, for roasting, free range	Chicken, non-specific cuts, frozen
	Chicken, live	Chicken, whole, frozen
	Chicken, non-specific cuts, fresh	Grilled/roasted chicken
	Chicken, whole, fresh	Ham, turkey, WKB
	Native house chicken, fresh	Luncheon Chicken
	Turkey	
	Turkey breast, fillet	
	Whole duck, fresh	
Fish	Black pomfret	Breaded fish fillet (Cod), 2 - 5 pieces, frozen, WKB
	Capitaine	Breaded fish fillet (Pollock), 2 - 4 pieces, frozen, WKI
	Carp	Calamari rings, frozen, WKB
	Catfish	Canned sprats in oil, WKB (CIS)
	Cod (gadus morhua)	Cod (Gadus morhua), frozen, WKB
	Fissikh	Cold-smoked salmon, WKB
	Fresh Small Sardines	Dried Machoirion, BNR
	Giant Shrimp	Dried sardines, BNR
	Grouper (Hamour) fish	Dried shrimps, BNR
	Lobster	Dried small fish, BNR
	Mackerel, un-cleaned	Fish fingers, BL
	Mud crab	Fish fingers, from fillet, WKB
	Mullet	Fishball, BNR
	Prawn/Shrimp, medium	Hake (Merluccius merluccius), Alaska Pollock (Theragra chalcogramma), fillet, frozen, WKB
	Prawn/Shrimp, small	Mackerel fillet, tinned, in tomato sauce, WKB
	Rainbow-Trout (Salmo gairdneri)	Mackerel fillet, tinned, in vegetable oil, WKB
	Red Snapper (AFR)	Mackerel in vegetable oil, WKB
	Red snapper	Pangasius catfish (Pangasius hypophthalmus), fillet, frozen, BL
	Safi	Salmon in natural juice, WKB (CIS)
	Sea bass	Salted and semi-dried fish, BL
	Sea crab	Salty herring (CIS)
	Sea lobster	Sardines in tomato sauce, WKB
	Shrimps, whole, fresh	Sardines, tinned, with skin, in vegetable oil, WKB
	Small fresh fish	Shrimps, peeled, frozen
	Sole	Smoked mackerel (Scomber scombrus), fillet, WKB
	Spanish Mackerel	Smoked shrimps/prawns, BNR
	Squid	Tinned pink tuna (Skipjack, Thunnus Thynn, Albacares = yellow fin), WKB
	Squid, small	Tinned sardines, in olive oil, with skin and bones, WKB
	Tilapia	Tinned tuna flakes, in vegetable oil, BL
	Tuna	Tuna flakes, tinned, WKB
	Tuna fish fresh	Tuna in vegetable oil, exclude Tuna Steaks, WKB
	Tuna steak	
	Tuna steaks	
White pomfret		

Table A5 (continued)

<i>Food</i>	<i>Raw (more work required)</i>	<i>Transformed (less work required)</i>
Carbo-hydrates (starchy staples)	Basmati rice, WKB	Baguette, BNR
	Broken rice, 25%, BNR	Bread unpacked
	Brown flour	Bread, mixed
	Brown rice, family pack, BL	Bread, multicorn
	Brown rice, loose	Bread, multicorn, industrially packed, WKB
	Buckwheat (CIS)	Bread, white, industrially packed, WKB
	Corn	Bread, white, loaf, BNR
	Corn (maize) flour, loose, BL	Bread, white, sliced, WKB
	Corn (maize) flour, white, WKB	Bread, white, toast, large pack, WKB
	Egyptian rice	Bread, white, unsliced, WKB
	Fresh cassava / manioc / yuca	Bread, white, large loaf
	Fresh potatoes, brown	Bread, whole wheat, loaf, BNR
	Fresh potatoes, industrially packed	Burger Bread
	Fresh potatoes, white	Couscous, BNR
	Fresh sweet potatoes	Dried noodles, WKB
	Fresh taro	Egg noodles, WKB
	Hard Loose Bulgur	Fresh rice noodles, BL
	Jasmine rice, WKB	Instant noodles, Cup, WKB
	Long grain rice, family pack, WKB	Instant noodles, any flavor, WKB
	Long-grain rice, not parboiled, BL or WKB	Lasagne
	Long-grained rice-25 to 50 KG,BNR	Lasagne (sheets)
	Long-grain rice, parboiled, WKB	Lebanese Bread
	Maize Flour White (Maizena)	Long-grain rice, parboiled in cooking bags
	Maize Flour, Yellow	Roll or bun, Prepacked, BNR
	Maize grains, White	Roll, BNR
	Maize, BL	Roll, multicorn
	Medium-grain rice, BNR	Round bread
	Millet (CIS)	Samoon Bread
	Millet, Sorghum, BL	Short pasta, BL
	Oats, Quaker	Short pasta, WKB
	Oats, rolled, WKB	Sliced brown bread (AFR)
	Plantains, Fresh Green	Sliced brown bread (WAS)
	Plantains, Fresh Ripe	Spaghetti, BARILLA
	Premium rice #1, Prepacked, BL	Spaghetti, BL
	Premium rice #2, Prepacked, BL	Spaghetti, WKB
	Premium rice #3, BNR	Sweet Bread
	Premium rice #4, BNR	Uncle Ben's rice
	Rice flour, Atta, WKB	Vermicelli, BL
	Risotto rice, WKB	Wheat tortillas, WKB
	Round-grain rice, WKB	
	Short-grain rice, BNR	
	Sticky rice, WKB	
	Sun White Rice - Australia	
	Wheat	
Wheat flour, WKB		
Wheat flour, loose, BNR		
Wheat flour, not self-rising, BL		
Wheat semolina (suji), WKB		
White rice #1, #3 or #5, BNR		
White rice #10, Prepacked, BL		
White rice #7, Prepacked, BL		
White rice #8, Prepacked, BL		
White rice #9, Prepacked, BL		
Wholemeal flour, Atta, BL		

Table A5 (continued)

<i>Food</i>	<i>Raw (more work required)</i>	<i>Transformed (less work required)</i>
Oils	Coconut oil, BL Corn Oil Corn oil, WKB Cottonseed oil (CIS) Olive oil, extra virgin, BL Olive oil, extra virgin, WKB Olive oil, standard, WKB Palm oil unrefined, BL Palm oil, WKB Peanut oil, WKB Soybean oil, WKB Sunflower oil, BL Sunflower oil, WKB Tahina Vegetable oil, WKB	
Onions	Fresh leek Fresh onions	
Tomatoes	Fresh tomato cluster Fresh tomatoes, round	Chopped tomatoes, BL Chopped tomatoes, WKB Tomato paste (Large), WKB Tomato paste, WKB Tomato puree (Passata di Pomodoro), WKB

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