Food and nutrition security in Kibera (Nairobi, Kenya)

with a focus on protein and amino acids

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Institute: Wageningen Food & Biobased Research

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1 Introduction

Based on the Household Survey undertaken in Kibera, a neighborhood and slum in the capital of Kenya, Nairobi, (see Ayuya et al. (2021) for full details) this study aims to understand food and nutrition security in this settlement. The quality of daily menus and macronutrient contents (carbohydrates, fats and – for the focus of this study particularly important - protein) are important aspects to monitor and improve upon. The question to be addressed here is: “Does the current diet of Kibera residents provide sufficient protein to meet nutritional needs?” The household survey contains several items related to food consumption and diet composition, but gives relatively limited information about macronutrient intake. Using this information from the survey, and supplementing this with information from secondary sources, we will attempt to produce a comprehensive overview of protein consumption in Kibera.

2 Data and Method

The Kibera household survey (Ayuya et al., 2021) provides information about food consumption behavior, with a strong focus on animal protein sources and fish in particular, as lack of protein in the diet is one of the major challenges affecting slum dwellers, and fish (already relatively easily available from lake Victoria) is a potentially feasible and effective protein source to reduce deficiency. 385 randomly selected households were targeted using a structured questionnaire. A two-stage cluster sample design was adopted for the survey. Kibera was clustered in 13 villages with an equal sample size allocated. One village was excluded due to security issues. Data was collected through personal interviews with randomly selected household heads. We focus predominantly on protein intake from animal sources because of the nature of the Kibera survey. The sections below shows how – based on survey data supplemented with information from secondary sources – we estimate protein intake from animal sources.

2.1 Animal protein sources - Fish

Data on fish consumption from the household survey is combined with data on nutrient (protein) content of the different types of fish. To approximate the protein consumption from fish per capita per month, we calculate the following for each type of fish (Tilapia, Catfish, Silver cyprinid, Common Carp, Nile Perch):

$$Protein\ from\ fish\ per\ capita\ per\ month = \left(\frac{Amount\ per\ purchase * purchases\ per\ month}{Household\ size}\right) * Protein\ content$$

Where the amount per purchase, number of purchases per month, and household size are taken from the questionnaire itself, and the protein content of the individual types of fish are taken from the USDA FoodData Central database (USDA, 2020) or – if not available through USDA – other sources. We assume the fish is bought fresh; nutritional information is collected for fresh fish.

Table 1 Protein content of fish types.

Fish	Protein content (g/100g)	Source
Tilapia	20	(USDA, 2020)
Catfish	16	(USDA, 2020)
Silver cyprinid	17	(Tieli et al., 2017)
Common carp	18	(Nutritionvalue.org, 2020)
Nile perch	19	(Okeyo et al., 2009)

Subsequently, total monthly protein intake per capita from fish is calculated by adding up the monthly protein intake figures for the five individual types of fish.

2.2 Other animal protein sources

For two other animal protein sources, dairy and meat, we can also approximate monthly intake. From the questionnaire we know the total weekly household spending on meat (labeled m8meat_value in the questionnaire data) and dairy (labeled m8dairy_value). We supplement this with information about prices and protein content.
For dairy, we assume this is mostly milk – a justified assumption based on the responses to survey item m8dairy1 ("Which types of dairy products (including milk) do your household members eat?"), to which 315 respondents answer "Fresh milk", 7 answer "Sour Milk", and 5 answer ""Yoghurt". This facilitates calculations because price data for milk is readily available (World Food Programme, 2020).
Also for ease of analysis, we assume that the meat consumption of Kibera households is a 50/50 mix of chicken (boneless breast) and beef (boneless). Furthermore, we assume the reported purchases are of raw animal products. This assumption is relatively safe to make, as differences in protein content between beef

and chicken are not extremely large (all in the range of 20-25g of protein per 100g raw product, depending on the cut).
The table below shows the reference values that we use for analysis based on these assumptions.

Table 2 Reference values used to impute protein intake from meat and dairy sources.

Variable	Value*	Source	Note
Dairy consumption	KSh/week/household	Survey	m8dairy_value – "How much do you spend on dairy products per week?"
Dairy price	44 KSh/500ml	(World Food Programme, 2020)	Price given for "Milk, cow, pasteurized" in Nairobi
Dairy protein content	3.4g/100ml	(USDA, 2020)	Average of USDA database items for milk
Meat consumption	KSh/week/household	Survey	m8meat_value – "How much do you spend on meat per week?"
Beef price	675 KSh/kg	(Kenya Meat Processors, 2020)	Average price per kilogram for types of boneless meat (beef steak-chucks, fillet, steak, minced beef)
Chicken price	600 KSh/kg	(Kenya Meat Processors, 2020)	Price per kilogram of boneless breast
Meat price (proxy)	637.5 KSh/kg		Average of approximated beef and chicken prices
Beef protein content	21.5g/100g	(USDA, 2020)	Average for USDA database items
Chicken protein content	26.1g/100g	(USDA, 2020)	Average for USDA database items
Meat protein content (proxy)	23.8g/100g		Average of approximated beef and chicken values

* KSh is Kenyan Shillings

Similar to the approach used for fish above, the total monthly per capita protein intake from animal sources is estimated by adding up the results of the following calculations (multiplying weekly spending by 4.35 to obtain monthly spending):

$$Protein\ from\ dairy\ (gram\ per\ capita\ per\ month) = \frac{\left(\frac{(Dairy\ spending\ per\ week * 4.35)}{Milk\ price\ per\ liter}\right)}{Household\ size} * Protein\ content\ of\ dair$$

$$Protein\ from\ meat\ (gram\ per\ capita\ per\ month) = \frac{\left(\frac{(Meat\ spending\ per\ week * 4.35)}{Meat\ price\ per\ kilogram}\right)}{Household\ size} * Protein\ content\ of\ meat$$

2.3 Kenyan protein consumption

The Kibera household survey seems to provide sufficient information to estimate protein intake per capita from animal sources (particularly fish). Estimated monthly protein intakes from these sources are added to estimate the monthly protein intake from animal sources.
To establish a frame of reference, also the average Kenyan protein consumption of animal protein sources is calculated. The protein intake from different food categories is based on average per capita consumption from Food Balance Sheets (FAO, 2020) and average protein content of these food types from food composition tables (USDA Food Composition Database, Standard Tables of Food Composition in Japan, and Food Data from National Food Institute, Technical University of Denmark). In addition, to estimate nutrient requirements we take into account information about the average body weight of Kenyans.

2.4 Quantitative approach

For analysis of the (supplemented) household survey data, we estimate protein intake from fish based on drivers of food and nutrition security (income, availability, cost) using ordinary least squares (OLS) regression. Because of lacking detailed information on fish prices, except for tilapia, and because tilapia is consumed the most by the respondents, we assume (realizing this is a strong assumption) that the price of tilapia represents the average for all fish species. In addition, we use a similar model to explain protein intake from dairy and meat sources (imputed as described above) based on income. Overall, we use the following variables.

Table 3 Variables used for regression models.

Variable type	Variables used	Source (survey item or other)	Level
Dependent	Protein from fish	See above	Integer (grams/capita/month)
	Protein from meat	See above	Integer (grams/capita/month)
	Protein from dairy	See above	Integer (grams/capita/month)
	Protein from animal sources	See above	Integer (grams/capita/month)
Independent	Income	Total household income (added from different income sources) divided by total household size (m4hhsize)	Integer (KSh/capita/month)
	Fish availability	m921fish_available – "Is the fish always available when you go buy it?"	Binary no/yes (0/1)
	Fish price (tilapia price as proxy)	m922tilapia_p – "What is the price per kilogram tilapia?"	Integer (KSh)
	Distance from fish outlet	m92fish_distance - "What is the distance from your house to where you mostly purchase fish in walking minutes?"	Integer (minutes)

To prepare the raw data needed for the regression model, new variables are calculated as described above, and outliers are removed. We consider respondents who report animal protein consumption of 10 times the average or more to be outliers, likely indicating an erroneous response, and remove these from the data. This produces the following summary statistics for the variables to be used:

Table 4 Summary statistics.

Variable	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Fish protein	381	136.327	152.836	0.000	34.000	182.000	908.333
Meat protein	381	80.925	90.859	0.000	20.300	108.267	649.600
Dairy protein	381	103.840	104.411	0.000	31.307	156.534	657.443
Animal protein	381	321.092	256.267	0.000	138.510	420.640	1,475.265
Income	381	3,405.525	3,421.899	0.000	1,333.333	4,000.000	24,000.000
Distance from fish outlet	350	11.037	11.062	0.000	5.000	10.000	90.000
Fish availability	349	0.653	0.477	0.000	0.000	1.000	1.000
Tilapia price	201	374.552	106.686	200000	300.000	400.000	1.000.000

3 Analysis

3.1 Protein consumption in Kenya and Kibera

In this section we explore the (animal and plantbased) protein intake of Kibera citizens, and assess how the diet (particularly protein intake) of the average Kibera resident is in any way comparable to the diet of the average Kenyan.
From information from FAO Faostat Food Balance Sheets (2018), combined with food composition tables, we can estimate the national average total daily protein intake per capita, and relative importance of different protein sources in the average Kenyan's diet. For Kenya overall, the average total protein intake per day is 72.73 grams, of which 16.61 grams from animal products (8.81g meat (of which 5.65g bovine meat), 6.61g dairy products the other 56.12 grams from vegetal sources (predominantly cereals, maize, pulses, wheat and beans). The figure below shows this breakdown, highlighting the importance of animal protein sources in the average Kenyan diet. The tables show the most important animal and plant protein products for 90% of food consumption.

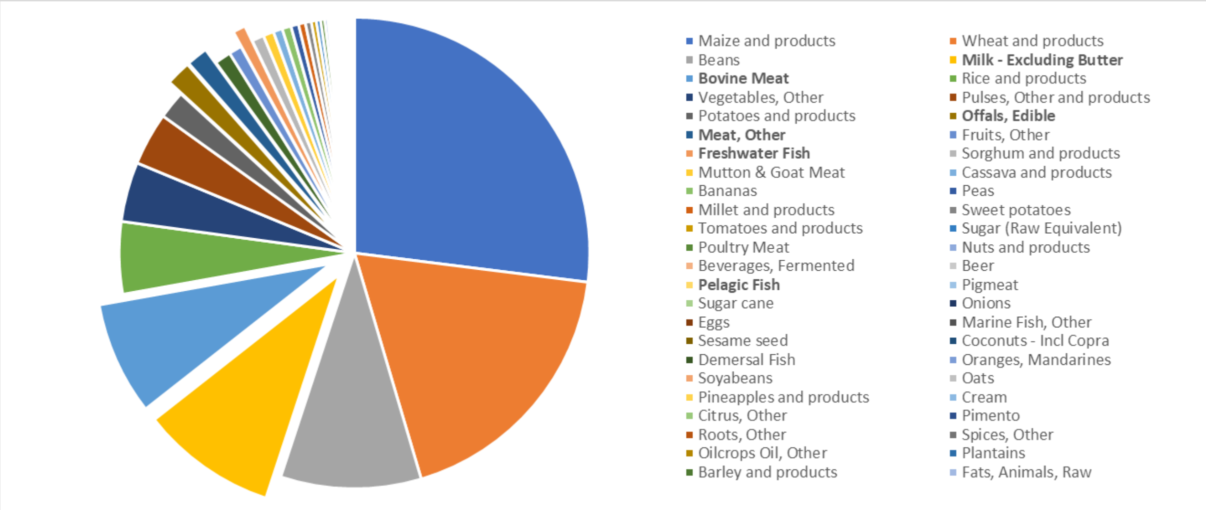

Figure 1 ***Protein sources in average Kenyan diet (2013) based on Groot (2021-1)***

Table 5 ***National total consumption of animal based protein up to >90% of total.***

Product group	Protein supply (ton/year)	Percentage from total national animal-based protein supply
Dairy - Excluding Butter	127,611	41.0%
Bovine Meat	106,005	34.0%
Offals, Edible	23,412	7.5%
Meat, Other	20,045	7.4%
Freshwater Fish	11,876	3.8%
Total animal-sourced protein supply		**92.7%**

Table 6 National total consumption of plant based protein up to >90% of total.

Product group	Protein supply (ton/year)	Percentage from total national plant-based protein supply
Maize and products	368,030	35.0%
Wheat and products	251,564	24.9%
Beans	131,716	12.6%
Rice and products	67,560	6.4%
Vegetables, Other	55,933	5.3%
Pulses, Other and products	49,470	4.7%
Potatoes and products	26,160	2.5%
Total plant-sourced protein supply		**91.4%**

From the household survey, protein intake from three major animal protein sources was approximated. The table below compares estimated protein intake in Kibera (g/capita/day, calculated by dividing the calculated monthly figures by 30) based on the household survey to Kenyan national average protein intake imputed from food balance sheets.

Table 7 Protein intake from animal sources – Kibera household survey versus Kenyan average.

Protein source	Average protein intake Kibera (g/capita/day)	Average protein intake Kenya (g/capita/day)
Fish	4,54	0,89
Meat	2,7	8,81
Dairy	3,46	6,91
Animal protein total	**10,7**	**16,61**

The household survey provides a fairly complete picture of fish consumption, and suggests that the average Kibera citizen consumes almost five times more protein from fish as the average Kenyan. This might be a overestimation from the respondents, or a result from the selection method of selecting the households. Whithin each cluster the same amount of households were interviewed. The selected clusters are old villages composed of different tribes and population sizes. On the other hand, the average protein intake in Kenya also includes a large number of people that probably does not eat fish at all. Protein intake from meat and dairy in Kibera is considerably less than the national average, which could be due to the relative cost and/or availability of meat and dairy in the Nairobi suburb, or due to survey respondents not including certain types of meat or dairy in their response for questions related to these products (e.g. some may not consider chicken to be meat, or count certain types of food like the 'Mutura' sausage as 'snacks' or 'fast food' rather than meat or dairy specifically). Moreover, eggs and seafood may not be included in survey responses at all. Overall, this comparison suggests that Kibera residents eat considerably less protein from animal sources than the average Kenyan. This however, should come with the caveat that information on consumption of animal protein sources other than fish is limited in the survey data.

The average Kenyan weighs 62.85kg (average of 63.9kg for men and 61.8kg for women) (WorldData, 2020). The WHO specifies a daily protein requirement of 0.8g protein per kg of bodyweight for healthy adults (Gezondheidsraad, 2001), which would imply a daily requirement for the average Kenyan of 50.28 grams of protein. The 72.73 grams of average total daily protein intake would suggest that the average Kenyan consumes more than sufficient protein. We showed above that estimated animal protein intake of Kibera residents is +/- 6 grams lower than the national average. Assuming that this value is correct and that Kibera residents' body mass and vegetal protein consumption are close to the national average, it seems that protein consumption of Kibera residents is still sufficient. However, if consumption of vegetal protein is also less than the national average (for example due to the distance from rural production areas and deficient infrastructure and logistics networks), nutrition security may be at risk in Kibera. When the same ratio is used with plant protein intake as with animal protein intake (10.7/16.61 = 64.4%), total protein intake in Kibera is estimated to be 46.85 grams per day per person. This is actually less than the average daily requirements. Unfortunately we cannot derive a conclusive conclusion as the survey data does not include data for plant protein sources.

3.2 Amino Acid consumption in Kibera and Kenya

Below we present an analysis on the essential amino acid intake and requirements of Kibera residents and how this relates to the essential amino acid intake for an average Kenyan. As shown in section 3.1, mainly intake from fish is available from the survey data in Kibera. Comparing the available data with amino acid requirements give an insight on what type of food products are complementary in order to have a healthy amino acid intake. Amino acids in food items are derived from Groot et al. (2021-2). This food composition database has been linked to FAO Faostat Food Balance Sheet data (2018). In this way we can show amino acids in food at country level.

Figure 2 shows the total amount of essential amino acids The data from the Food Composition database has raw as well as processed food items listed. Looking at Lysine for example (relative high levels in animal food products) we can see on average 63% more is available in food than required. This is for Kenya on country level. For specific population groups this means perhaps a shortage in Lysine intake.

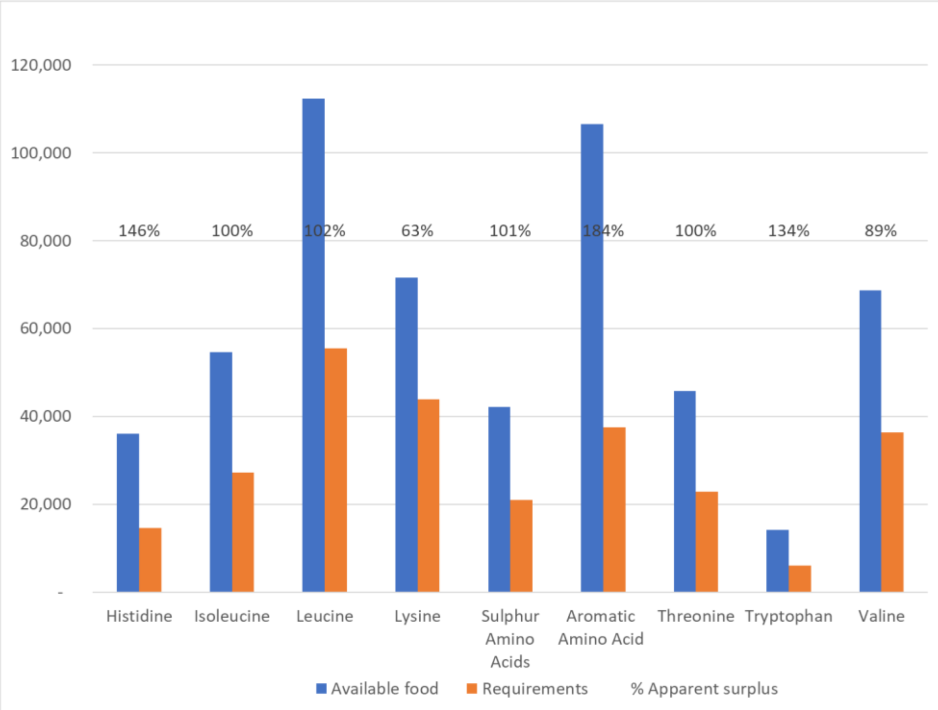

Figure 2 ***Amino Acids in food and required (Kenyan total, 2018, tons)***

Derived from the data from the survey a person in Kibera consumes approximately 24.4 gram of fish per day. The amino acid ratio of Nile Tilapia consumed by consumers in Kibera has the following amino acid composition as shown in Figure 3.

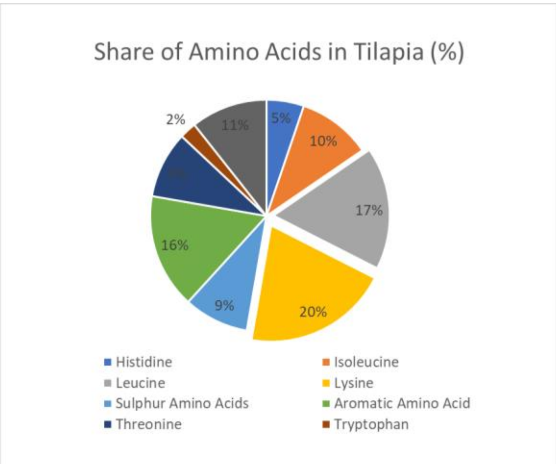

Figure 3 ***Amino Acids ratio in Tilapia***

Tilapia (and fish in general) have compared to the composition of the daily requirements a relatively low amount of branched chain amino acids (BCAA's, isoleucine, leucine and valine) and leucine. A diet only on fish might result in health problems due to deficiencies of the mentioned amino acids (Gibson et all., 2003). Food groups with relative high levels of BCAA's are meat, dairy and pulses. These product groups are as well good sources for Lysine. Therefore nutritional attention for meat, dairy (lower intake than national average, see Table 7) and/or pulses in a Kibera diet is important.

Table 8 Share of amino acids in fish, compared with daily requirements.

Amino Acid	Requirements	Tilapia	Difference between Requirements and Tilapia
Histidine	5.5%	5.2%	94.5%
Isoleucine	10.3%	10.2%	99.3%
Leucine	20.9%	17.0%	81.4%
Lysine	16.5%	20.2%	122.4%
Sulphur Amino Acids	7.9%	9.1%	114.3%
Aromatic Amino Acid	14.2%	16.0%	112.8%
Threonine	8.6%	9.3%	107.4%
Tryptophan	2.3%	2.3%	102.7%
Valine	13.7%	10.6%	77.6%

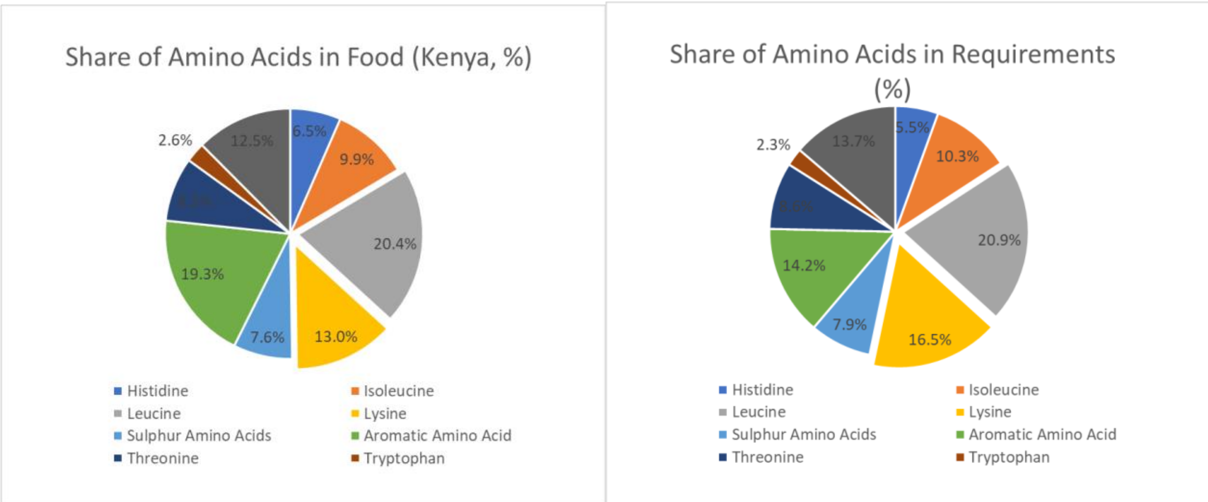

Figure 4 Amino Acids ratio in Kenyan food and in the daily requirements

3.3 Explaining nutrition security

The household survey also provides information about Kibera residents' situation regarding income and access to food. As outlined above in Section 2, we attempt to explain protein intake from animal sources based on these factors using OLS regression. First we take a closer look at fish consumption and factors influencing fish consumption, since the survey data provides most information on fish compared to other animal protein sources.

Table 9 Regression results for protein intake from fish.

	Dependent variable:	
	Protein from fish	
	(1)	(2)
Income	0.012***	0.014***
	(0.002)	(0.003)
Distance from fish outlet		0.579
		(0.928)
Fish availability		16.949
		(24.095)
Fish price		-0.326***
		(0.104)
Constant	95.096***	238.881***
	(10.654)	(44.842)
Observations	381	197
R^2	0.073	0.120
Adjusted R^2	0.071	0.102
Residual Std. Error	147.308 (df = 379)	154.067 (df = 192)
F Statistic	30.057*** (df = 1; 379)	6.560*** (df = 4; 192)
Note:		*p<0.1; **p<0.05; ***p<0.01

The simplest model (1) shows that income has a significant positive effect on protein intake from fish. The more elaborate model on the right (2) shows that this effect is robust to the inclusion of other factors that may influence fish consumption. Of these factors, the cost of fish has (as expected) a significant negative effect on fish consumption. The availability of fish and the distance from the nearest fish outlet are not significant factors for consumption of protein from fish.
The table below shows the results of regressions explaining variation in protein intake from all animal sources (individual and total) based on income.

Table 10 Regression results for protein intake from animal sources.

	Dependent variable:			
	Fish protein	Meat protein	Dairy protein	Animal protein
	(1)	(2)	(3)	(4)
Income	0.012***	0.013***	0.010***	0.035***
	(0.002)	(0.001)	(0.001)	(0.003)
Constant	95.096***	37.202***	69.659***	201.957***
	(10.654)	(5.760)	(7.141)	(16.410)
Observations	381	381	381	381
R^2	0.073	0.234	0.108	0.218
Adjusted R^2	0.071	0.232	0.106	0.216
Residual Std. Error (df = 379)	147.308	79.636	98.731	226.889
F Statistic (df = 1; 379)	30.057***	115.652***	45.984***	105.780***
Note:				*p<0.1; **p<0.05; ***p<0.01

Increases in income lead to increases in animal protein consumption across the board. The effect is relatively consistent in size and significance across animal protein sources. The magnitude of the estimated constants show that Kibera residents get their animal protein predominantly from fish, followed by dairy and meat. Overall, income explains 21,6% of variation in total animal protein consumption, and for meat this relationship is particularly strong as well (Adj. R^2 = 0.232).

4 Discussion and further research

Based on the information from the Kibera household survey, it is hard to draw definite conclusions about nutrition security in Kibera. What we can conclude is that for those Kibera residents who do not have access to sufficient protein, their income and the price of protein sources are more important limiting factors than the availability. This conclusion comes of course with the caveat of rough approximations that were used to estimate dairy and meat consumption, and we did not take into account protein intake from vegetal sources. The findings suggest that fish is more critical for Kibera residents' protein intake than it is for the average Kenyan.

These findings invite further questions:

- Do Kibera residents have access to sufficient protein? The results suggest that their animal protein intake is below the national average, but they may supplement this with more protein from vegetal products. Moreover, the survey may not capture consumption of specific sources of animal protein.
- How available are meat, dairy, other animal protein sources and pulses for Kibera residents? The fact that their estimated protein intake from fish is almost five times the national average suggests that fish is relatively abundantly available at affordable prices, compared to other animal products, of which they seem to consume less than the national average.
- What other protein sources do Kibera residents consume? And: In what quantities are these consumed, and how is the availability? Vegetal products constitute approximately three fourths of protein sources in the average Kenyan diet, and are therefore important to fully understand food and nutrition security.

For further survey research, we recommend more detailed information to be collected about the consumption of dairy, meat, and other key protein sources (e.g. cereals, maize, wheat, pulses and beans) including prices, purchase size and frequency, and access and availability – similar to the information collected for different types of fish in the present survey.

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