Assessing an increase of orphan crops in the Kenyan diet

by Cesar Revoredo-Giha, Hasibi Zavala-Nacul, and Luiza Toma

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Cesar Revoredo-Giha (contact author)
Hasibi Zavala-Nacul
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Abstract

Orphan crops are those crops that did not receive the same attention of the research community as in the case of staples like wheat, maize or rice despite their regional and nutritional importance. A relatively recent trend has been to promote research to improve their productivity and resilience to environmental shocks. Their impact on consumers' nutrition has, however, been analysed only considering the crops individual characteristics and not in the context of the diet, where the increase on the consumption of one product may trigger changes on the other products that conform the diet. The purpose of this paper is to assess the potential impact, in terms of food choices and nutrition, of increasing the consumption of orphan crops (e.g., millet) on the Kenyan diet. This was done using a microeconomic-based methodology, which augments the original consumer problem with a constraint regarding the amount of the orphan crop on the diet. To compute the required elasticities for the method, three demand systems – i.e., for rural, less affluent urban, more affluent urban households - were estimated using the 2015-16 Kenyan Integrated Household Survey and the two-step approach to address the zero consumption for some food categories; the second step was modelled using the Linquad demand model. The results indicate that although the orphan crops have the capacity to improve some of the nutrients (e.g., vitamins and minerals), in net terms as measured by the aggregated nutritional indicator the improvement is somewhat limited; however, the improvements occur on the rural and the less affluent population.

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Abstract

Orphan crops are those crops that did not receive the same attention of the research community as in the case of staples like wheat, maize or rice despite their regional and nutritional importance. A relatively recent trend has been to promote research to improve their productivity and resilience to environmental shocks. Their impact on consumers' nutrition has, however, been analysed only considering the crops individual characteristics and not in the context of the diet, where the increase on the consumption of one product may trigger changes on the other products that conform the diet. The purpose of this paper is to assess the potential impact, in terms of food choices and nutrition, of increasing the consumption of orphan crops (e.g., millet) on the Kenyan diet. This was done using a microeconomic-based methodology, which augments the original consumer problem with a constraint regarding the amount of the orphan crop on the diet. To compute the required elasticities for the method, three demand systems – i.e., for rural, less affluent urban, more affluent urban households - were estimated using the 2015-16 Kenyan Integrated Household Survey and the two-step approach to address the zero consumption for some food categories; the second step was modelled using the Linquad demand model. The results indicate that although the orphan crops have the capacity to improve some of the nutrients (e.g., vitamins and minerals), in net terms as measured by the aggregated nutritional indicator the improvement is somewhat limited; however, the improvements occur on the rural and the less affluent population.

Keywords: Orphan crops, nutrition, healthy consumption.

I. Introduction

Orphan crops are those crops that did not received the same attention of the research community as in the case of staples like wheat, maize or rice despite their regional and nutritional importance. A relatively recent trend has been to promote research to improve their productivity and resilience to environmental shocks (McMullin et al., 2020).

Their impact on consumers' nutrition has, however, been analysed only considering the crops individual characteristics and not in the context of the diet, where the increase on the consumption of one product may trigger changes on the other products that conform the diet (e.g., Stadlmayr et al., 2013; Borelli et al., 2020). This is important because the resulting impact of the increase in the orphan crop is the net nutritional effect on the diet.

The purpose of this paper is to assess the potential impact, in terms of food choices and nutrition, of increasing the consumption of orphan crops (e.g., millet) on the Kenyan diet considering three socioeconomic groups (rural, urban less affluent and urban more affluent). This assessment was done using a microeconomic-based methodology, which augments the original

consumer problem with a constraint regarding the amount of the orphan crop on the diet.

This study shows the importance to consider consumers' preferences when introducing new products or expanding current products on the diet as the results indicate that the net effect on nutrition is not as impressive than when the introduction of a product is considered in isolation (i.e., not in the context of the diet).

The structure of this paper is as follows: it starts with a literature review; next, the methodology is presented, comprising the simulation method, the estimation of the needed elasticities and the data used for the estimation. Then, the results are discussed. Finally, conclusions are presented.

II. Literature review

The supply of products that respond to consumer preferences can be seen as an effective tool to support healthy diets in situations where consumers face complex choices. This is needed as Africa's consumer markets are showing an expansion of ultra-processed products (Moodie et al., 2013), a fact that could be associated to increasing levels of non-communicable diseases.

The aforementioned ultra-processed foods are displacing more traditional dietary patterns, which are based on fresh and perishable whole or minimally processed foods, some of which are orphan crops. The consumption of these products is more suitable socially, environmentally and nutritionally.

Research has indicated that orphan crops, which include a range of fruits, vegetables, legumes, grains and roots, offer the possibility to support greater food diversification in Africa (Frison et al., 2006; Mabhaudhi et al., 2016; McMullin et al., 2020).

Food diversification (Kumar et al., 2015), which is an alternative to the crop biofortfication approach, is founded on increasing the range of nutritious crops grown (Keatinge et al., 2010) that are available for the farmers. This not only increases food system resilience under the variable weather due to less risk and the properties of those crops (Dawson et al., 2019) but also have the possibility to improve nutrition (Stadlmayr et al., 2013, 2019).

It is important to note that the impact of orphan crops on consumption and nutrition depends on their uptake by consumers (and potentially to other stakeholders in the supply chain such as processors) because only then these crops can helps ensure producers a fair and sustainable return for their products, connecting them with markets, itself an effective tool against poverty (African Development Bank Group, 2016).

In order to appeal to consumers orphan crops cannot be a mere afterthought, nor can they simply be framed in terms of development policy or agricultural advantages (Chera, 2017). As she pointed out in the case of millets in India, potential nutritional, environmental, and economic benefits of embracing

agricultural biodiversity are not likely to be enough to change their preferences. It is, then, important to improve consumers appreciation for the crops.

The contribution of this paper is to analyse the impact on the Kenyan diet of expanding the quantity of orphan crop cereals on the diet under the current consumer preferences (i.e., without the influence of any campaign to increase consumers appreciation for these crops). This provides an assessment of the impact that more orphan crops may have on nutrition.

III. Methodology

This section starts presenting the evaluation method, followed by the approach to compute the required elasticities and finally the data used for the estimation.

III.1 Evaluation method

The approach used in this paper for the ex-ante evaluation of increasing orphan crops on the diet is based on Irz et al. (2015). A brief overview of the method is presented here for completeness sake. It is founded on the neoclassical consumer theory and assumes that consumers choose the consumption of a bundle of H goods in quantities $q = (q_1, \dots, q_H)$ to maximise a strictly increasing utility, quasi-concave, twice differentiable utility function $U(q_1, \dots, q_H)$, subject to a linear budget constraint $p.q \leq M$, where p and M are price and income vectors.

In this study, the above problem is modified by adding an additional constraint, which is the required level of orphan crops that enter into the diet. Mathematically, the additional constraints (called nutritional constrains in Irz et al., 2015) are express by $\sum_{i=1}^{H} a_i^n \, q_i \leq r_n, \quad \forall n = 1, \dots, N.$

To solve the modified version of the utility maximization problem, the procedure relies on the notion of shadow prices. Duality theory is used to relate the unconstrained Hicksian demand function $h_i(p, U)$ to the constrained model $\tilde{h}_i(p, U, A, r)$. Where A is the N X H matrix of nutritional coefficients, and r is the N vector of maximum nutritional amounts.

Shadow prices are calculated by maximizing $\tilde{C}_i(p, U, A, r)$ subject to $\sum_{i=1}^{H} a_i^n \, q_i \leq r_n, \quad \forall n = 1, \dots, N$. The Lagrangian of the virtual price problem (L) is expressed by:

$$L = C(\tilde{p}, U) + \sum_{j=1}^{H} (p_j - \tilde{p}_j) h_j + \sum_{n=1}^{N} \mu_n \left(r_n - \sum_{j=1}^{H} a_j^n h_j \right) \qquad (1)$$

Where μ_n is the lagrangian multiplier associated with the nth nutritional constraints. The Kuhn-Tucker conditions for (1) are based on the assumption of non-satiation and strictly positive virtual prices as:

$$\frac{\partial C}{\partial \tilde{p}_i} - h_i + \sum_{j=1}^{H}(p_j - \tilde{p}_j)\frac{\partial h_j}{\partial \tilde{p}_i} - \sum_{n=1}^{N}\mu_n \sum_{j=1}^{H} a_j^n \frac{\partial h_j}{\partial \tilde{p}_i} = 0, i = 1, \dots, H \quad (2)$$

$$\mu_n \left(r_n - \sum_{j=1}^{H} a_j^n h_j \right) = 0 \quad (3)$$

$$\mu_n \geq 0, n = 1, \dots, N \quad (4)$$

By applying Shepherd's lemma and replacing $\frac{\partial h_j}{\partial \tilde{p}_i}$ by s_{ij}, equation (2) reduces to:

$$\sum_{j=1}^{H}\left[(p_j - \tilde{p}_j) - \sum_{n=1}^{N}\mu_n a_j^n\right] s_{ij} = 0, \ i = 1, \dots, H \quad (5)$$

Assuming that all N equations are binding, the virtual price problem reduces to:

$$\tilde{p}_i = p_i - \sum_{n=1}^{N}\mu_n a_j^n, i, \dots, H \quad (6)$$

$$\sum_{j=1}^{H} a_i^n h_i(\tilde{p}_i, U) = r_1 \quad (7)$$

According to Irz et al. (2015), the first set of equations (6) implies that deviations between shadow prices and market prices are proportional to the nutritional coefficients of the goods entering the single nutritional constraint. The second set of equations (7) indicates that the nutritional constraints are binding. A change in the shadow price because of a change in the nutritional constraints can be expressed as:

$$\frac{\partial \tilde{p}_i}{\partial r_1} = \frac{a_i^1}{\sum_{i=1}^{H}\sum_{i=1}^{H} s_{ij} a_i^1 a_j^1}, \quad i, \dots, H \quad (8)$$

Also, a change in the Hicksian demand of product k due to a change in the nutritional constraints is express by:

$$\frac{\partial \tilde{h}_k}{\partial r_1} = \frac{\sum_{i=1}^{H} s_{ki} a_i^1}{\sum_{i=1}^{H}\sum_{i=1}^{H} s_{ij} a_i^1 a_j^1}, \quad k = 1, \dots, H \quad (9)$$

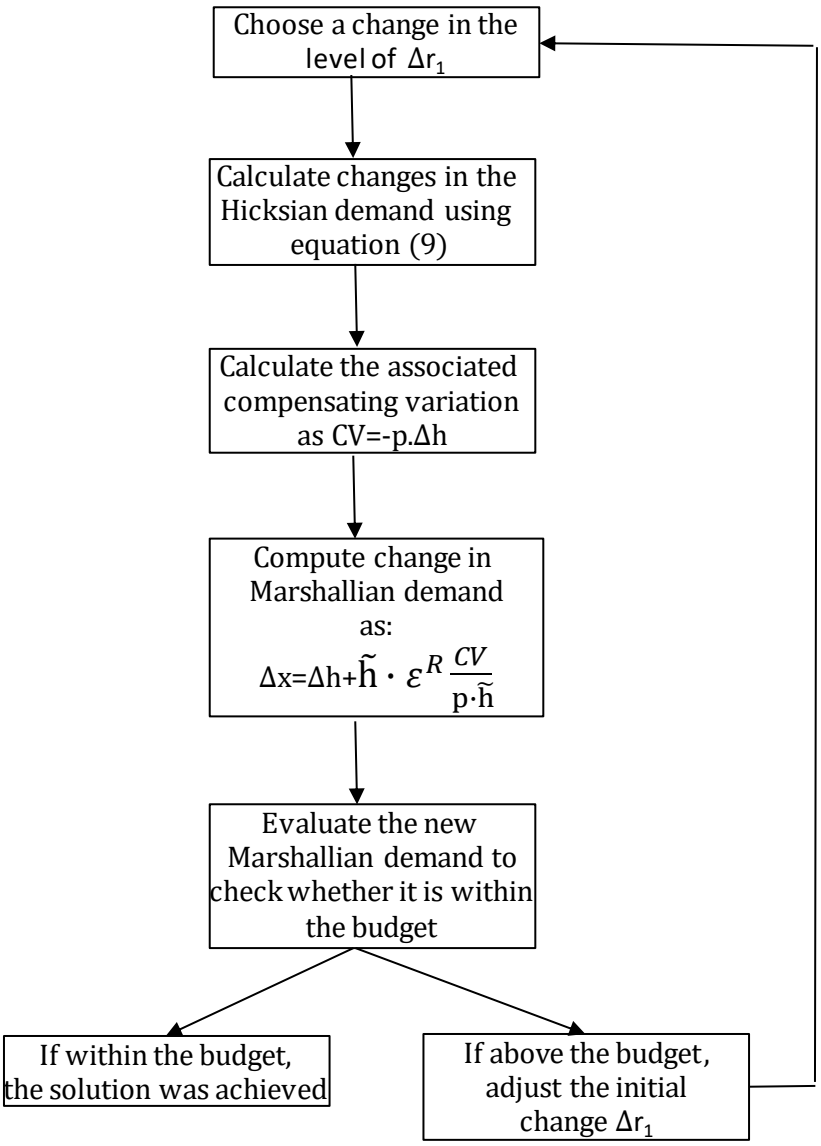
Equations (8) and (9) suggest that a change in the nutritional constraints have impact on the entire diet of the consumer through substitution and complementary relationships across food products. Equation (9) is used to evaluate how consumers react to a change in the nutritional requirement (in this case the amount of orphan crop in the diet). As (9) assumes that the level

of utility is the same, it is possible that it may exceed the original budget, therefore, it is needed to compute the change in the Marshallian demands which is given by (10)

$$\Delta x = \Delta h + \tilde{h} \cdot \varepsilon^{R} \frac{CV}{p \cdot \tilde{h}} \qquad (10)$$

Where $\Delta h = \left(\frac{\partial \tilde{h}_1}{\partial r_1}\Delta r_1, \ldots\ldots, \frac{\partial \tilde{h}_K}{\partial r_1}\Delta r_1\right)$, ε^{R} is the vector of income elasticities, CV is the compensating variation which is give by $CV = -p \cdot \Delta h$. Figure 1 present the flowchart with the simulation procedure.

Figure 1: Flowchart with the simulation procedure



Source: Own elaboration based on Irz et al. (2015).

This study also estimated the change in the nutritional value of the diet due to the inclusion of the orphan crops. This was done by computing the Mean Adequacy Ratio (MAR), which estimates the percentage of mean daily intake

of beneficial nutrients with 100 per cent representing a diet which would conform to all these nutritional requirements (Vieux et al., 2013). Note that the components of the MAR are truncated to 100 so excesses of one of the nutrients cannot compensate the lack of another nutrient. The formula of the MAR is given by (11), where c_i is the intake of nutrient i, R_i is the recommended intake of nutrient i, m is the number of nutrients.

$$\mathrm{MAR} = \frac{1}{m} \times \sum_{i=1}^{m} \frac{c_i}{R_i} \times 100 \tag{11}$$

III.2 Demand estimation

The assessment of increasing the quantity of orphan crops to the diet while keeping the amount of income constant requires the estimation of demand elasticities. A problem when estimating elasticities using household surveys is the censoring in response. As point out by Lema et al. (2007) some households might not consume certain food groups, resulting in a zero value for the dependent variable. This may be due to infrequency of purchase, consumers preferences (i.e., they actually do not consume the food group) or because consumers do not purchase the good at the current prices and income levels (i.e., corner solution).

To address the censoring problem the estimation was carried out using the Shonkwiler and Yen (1999) two-step procedure. The first step models the zero consumption with a selection mechanism given by (12):

$$\begin{cases} x_i^* = g(p, y) + \epsilon_i \\ d_i^* = z'_i \lambda_i + v_i \\ d_i = \begin{cases} 1 & \text{if } d_i^* > 0 \\ 0 & \text{if } d_i^* \leq 0 \end{cases} \\ x_i = d_i \cdot x_i^* \end{cases} \tag{12}$$

Where d_i and x_i are the observed value of whether the product i is purchased by the household, and the quantity demanded of the product. The '*' indicate latent variables; $g(p, y)$ is a function that depends on prices p and income y; ϵ_i and v_i are error terms, the z_i are variables affecting the decision of purchase and λ_i are the parameters of that function.

The unconditional expected value of system (12) is given by (13):

$$x_i = \phi \cdot g(p, y) + k_i \varphi + \varepsilon_i \tag{13}$$

Where ϕ and φ are the cumulative density and the standard normal density functions, k_i is a parameter and ε_i is an error term. The $g(p, y)$ needs to be approximated. Here this paper follows Fabiosa and Jensen (2003) and uses the Linquad demand system (LaFrance 1990, 1991, 1998). The final Marshallian demand specification of LinQuad model (LaFrance, 1990) is given by (14):

$$x = \alpha + Av + Bp + \gamma[y - p'\alpha - p'Av - 0.5p'Bp] \quad (14)$$

Where α, A, B, γ, $\delta(v)$ are vectors or matrices of parameters and v is a vector of demographic variables. The quadratic term in prices increases the flexibility in Slutsky symmetry removing the restrictions that constrain the preference ordering of a linear system. In addition, the LinQuad quasi-expenditure function is a second order Taylor series approximation to any arbitrary expenditure function. The prices and income elasticities adjusted by the selection mechanism are given by (Fabiosa and Jensen, 2003):

$$\eta_{ij}^{a} = \phi_i \eta_{ij}^{s} + \frac{\varphi_i \lambda_{ij} p_j}{x_i}\{x_i - \kappa_i(z\lambda)\} \quad (15)$$

$$\eta_{i}^{a} = \phi_i \eta_{i}^{s} + \frac{\varphi_i \lambda_{iy} y}{x_i}\{x_i - \kappa_i(z\lambda)\} \quad (16)$$

Where the original elasticities (not considering the selection mechanism) are given by:

$$\eta_{ij}^{s} = \left(\beta_{ij} - \gamma_i\left(\alpha_j + A_j v + B_j p\right)\right)\frac{p_j}{x_i} \quad (17)$$

$$\eta_{i}^{s} = \gamma_i \frac{y}{x_i} \quad (18)$$

The Hicksian elasticities were computed using the Slutzky formula $\eta_{ij}^{a*} = \eta_{ij}^{a} + \omega_j \eta_i^{a}$. The unconditional elasticities for the cereals and pulses category were computed using the formulas by Carpentier and Guyomard (2001).

III.3 Data used in the analysis

The data used came from the 2015/16 Kenya Integrated Household Budget Survey (KIHBS) which was conducted over a 12-month period to obtain up-to-date information on a range of socioeconomic indicators used to monitor the implementation of development initiatives (KNBS & MDNP, 2018).

The survey collected information on household characteristics, housing conditions, education, general health characteristics, nutrition, household income and credit, household transfers, information communication technology, domestic tourism, shocks to household welfare and access to justice.

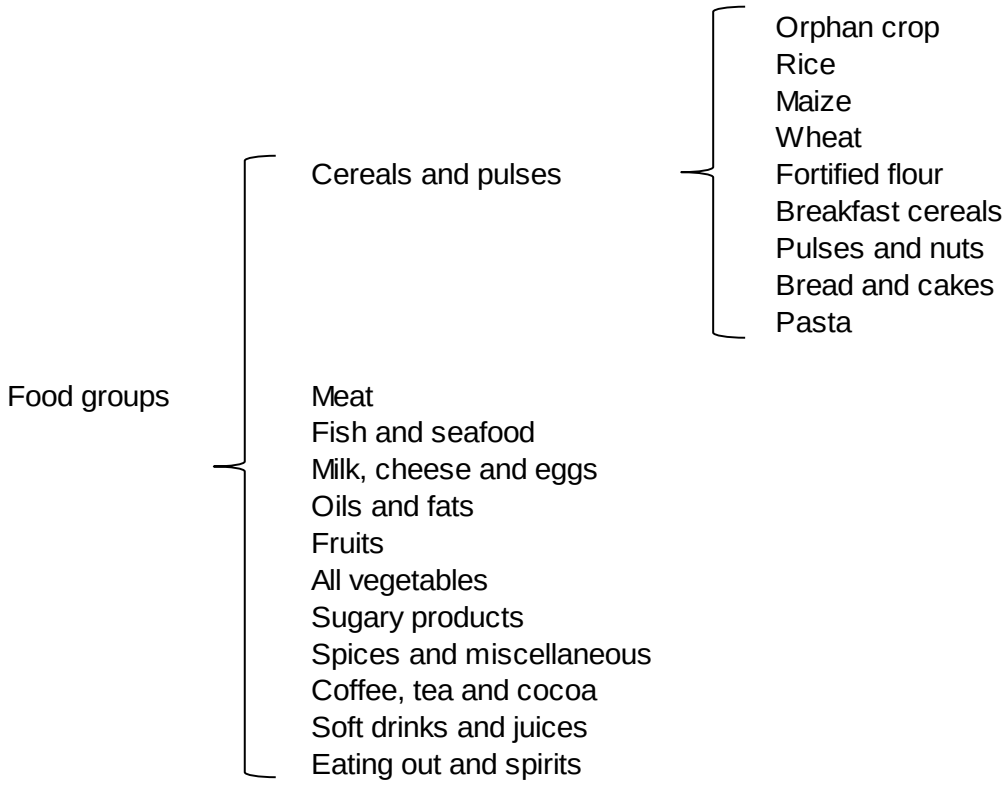
The KIHBS 2015/16 is a multi-indicator survey with the main objective of updating the household consumption patterns in all the Counties. KIHBS 2015/16 is designed to provide estimates for various indicators at the County-level. A total of 50 study domains are envisaged. These are: all the forty-seven (47) counties (each as a separate domain), urban and rural (each as a separate domain at National level), and lastly the national-level aggregate.

The sample for KIHBS 2015/16 is a stratified sample selected in two stages from the master sample frame. Stratification was achieved by separating each county into urban and rural areas; in total, 92 sampling strata have been created since Nairobi County and Mombasa County have only urban areas. Samples were be selected independently in each sampling stratum, by a two-stage selection. In total, the national sample size for KIHBS 2015/16 comprised a total of 23,880 households from 2,388 clusters. Note that the actual dataset has 21,754 observations after cleaning it.

The 2015/16 KIHBS data is weighted to be representative at the national level as well as at county level. The weighting was based on the selection probabilities in each domain. The design weights were adjusted using the survey response to give the final weights.

The survey collected information about consumption and expenditure on food items, regular non-food items and durable goods and services. The data comprised food purchased, net received, in stock in terms of quantities and expenditure. The food information was grouped as shown in Figure 2, where orphan crops millet grain, millet flour, cassava flour, sorghum grain, sorghum, flour, sesame seeds and mixed porridge flour.

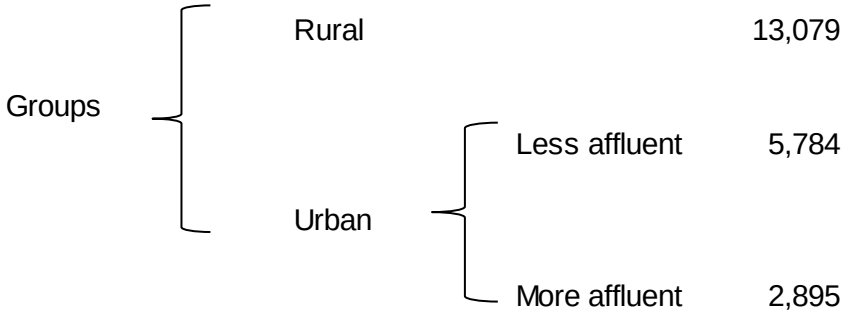
Figure 2: Food groups for the analysis.



Source: Own elaboration based on the 2015/16 KIHBS

As shown in Figure 3, the socioeconomic groups considered for the analysis were there: rural (13,079 households), urban less affluent (5,784 households) and urban more affluent (2,895 households). The less and more affluency was set based on total expenditure quintiles (i.e., the households in the lowest three urban expenditure quintiles were classified as the least affluent). Tables 1 and 2 provide information for each socioeconomic group.

Figure 3: Socioeconomic groups for the analysis.



Source: Own elaboration based on the 2015/16 KIHBS

The nutritional information used in the analysis was from the Kenyan Food Composition Tables (KFCT) (FAO/Government of Kenya, 2018). These tables provide very disaggregated data (energy, macronutrients and micronutrient) for a high number of food products.

Table 1: Descriptive statistics for each one of the socioeconomic groups in adult equivalent (units are in the note)

	Rural			Urban poor			Urban affluent		
	Quantity	Price	Zero (%)	Quantity	Price	Zero (%)	Quantity	Price	Zero (%)
Orphan crop	0.153	17.952	21.6	0.057	12.707	13.0	0.059	15.263	11.2
Rice	0.368	56.763	62.0	0.430	70.844	75.2	0.655	95.235	80.1
Maize	2.276	42.752	92.0	1.365	39.636	79.9	1.012	38.182	64.6
Wheat	0.143	15.913	22.1	0.142	15.953	23.1	0.188	18.146	27.0
Fortified flour	0.307	24.366	33.3	0.407	32.125	45.8	0.683	39.980	58.6
Breakfast cereals	0.001	2.503	0.4	0.000	4.882	0.6	0.011	45.956	6.7
Pulses and nuts	0.581	72.183	79.8	0.318	66.425	63.7	0.391	89.838	65.0
Bread and cakes	0.227	81.579	59.9	0.344	95.587	70.8	0.815	122.052	87.3
Pasta	0.009	4.830	2.9	0.020	13.352	8.0	0.059	40.911	21.6
Meat	0.228	176.825	50.6	0.181	217.849	42.3	0.606	320.333	19.6
Fish and seafood	0.083	116.944	66.8	0.069	135.475	65.3	0.122	155.006	65.1
Milk, cheese and eggs	1.758	69.783	11.3	1.241	90.492	11.7	2.289	99.738	6.3
Oils and fats	0.168	175.329	5.5	0.188	161.938	7.2	0.299	179.998	8.2
Fruits	0.900	38.732	28.5	0.742	53.706	19.1	1.792	69.315	6.1
All vegetables	2.872	43.954	6.0	2.196	54.580	5.1	3.787	54.573	6.5
Sugary products	0.631	95.173	5.3	0.394	99.895	6.8	0.449	121.626	8.2
Spices and miscellaneous	0.052	63.559	3.9	0.045	70.325	7.3	0.074	110.950	8.5
Coffee, tea and cocoa	0.024	489.460	7.4	0.024	522.454	10.4	0.044	549.160	11.4
Soft drinks and juices	0.113	20.442	80.2	0.127	23.098	77.0	0.912	51.226	44.4
Eating out and spirits	0.244	59.804	81.4	0.238	50.992	84.6	0.722	255.130	73.0
Total expenditure	1232.3			1415.2			4069.1		

Note 1/ Units in kg or lts per week per adult equivalent; prices are in Kenyan shillings per kg or lts. Total expenditure is in Kenyan shillings per week.

Source: Own elaboration based on the 2015/16 KIHBS

Table 2: Characteristics of each one of the socioeconomic groups

Category	Rural	Urban		Category	Rural	Urban	
		Less affluent	More affluent			Less affluent	More affluent
Total household members				**Area**			
Less or equal than 3	0.37	0.47	0.74	Government related	0.08	0.10	0.12
From 4 to 6 persons	0.43	0.41	0.24	Private sector	0.23	0.34	0.44
From 7 to 10 persons	0.19	0.11	0.02	NGO related	0.01	0.01	0.02
More than 10 people	0.02	0.01	0.00	Agricultural pastoralist	0.42	0.10	0.03
Gender of head of household				Informal sector	0.05	0.14	0.08
Female	0.36	0.29	0.27	Other	0.10	0.10	0.08
Male	0.64	0.71	0.73	**Richest counties**			
Number of children (lesser or equal than 10 years old)				Nairobi	0.00	0.20	0.42
None	0.34	0.41	0.63	Kiambu	0.03	0.08	0.09
Less than 3	0.56	0.54	0.36	Nyeri	0.03	0.02	0.02
More than 3 and less than 7	0.10	0.05	0.01	Kajiado	0.02	0.03	0.03
More than 7	0.00	0.00	0.00	Nakuru	0.05	0.06	0.06
Number of older (greater than 65 years old)				Kwale	0.02	0.01	0.01
None	0.34	0.41	0.63	Likipia	0.02	0.01	0.01
Less than 3	0.56	0.54	0.36	Murang'a	0.04	0.02	0.01
More than 3	0.10	0.05	0.01	Mombasa	0.00	0.07	0.09
Type of dwelling				Machakos	0.02	0.05	0.04
Bungalow	0.76	0.39	0.18	**Poorest counties**			
Flat	0.01	0.08	0.35	Mandera	0.01	0.01	0.00
Landhi	0.06	0.30	0.28	Bomet	0.02	0.01	0.00
Maisonnette	0.00	0.01	0.03	Elgeyo/Marakwet	0.01	0.00	0.00
Manyatta/traditional house	0.14	0.03	0.00	Samburu	0.01	0.00	0.00
Shanty	0.01	0.03	0.02	West Pokot	0.02	0.00	0.00
Swahili	0.03	0.16	0.13	Migori	0.03	0.01	0.00
Not stated or other	0.00	0.01	0.01	Turkana	0.02	0.03	0.01
Activity				Busia	0.02	0.01	0.00
Apprentice	0.00	0.00	0.00	Baringo	0.02	0.01	0.01
Contributing family worker	0.02	0.00	0.00	Homa Bay	0.02	0.02	0.01
Members of producers? cooperatives	0.00	0.00	0.00				
Own-account worker	0.55	0.33	0.31				
Paid employee (within hh)	0.15	0.19	0.11				
Paid employee (outside hh)	0.19	0.38	0.49				
Working employer...	0.00	0.00	0.01				
Volunteer or Other	0.09	0.09	0.08				

IV. Results and discussion

Tables 3 and 4 present the baseline and the results of the simulations by economic group. The simulations consisted of increasing the amount of orphan crop in the group diet two, three and four times. Note that these increases are not as big as they may sound due to the fact that the amount of cereal orphan crops in the diets were very small.

As shown in Table 3 the increase of orphan crops in the diet has effects on all the goods but these changes (note that they are in percentages) differ by food group and socioeconomic group. Moreover, in order to enter in those proportions in the diet price require to decrease significantly (as shown by the changes in shadow prices).

As shown in Table 3 most of the changes due to the expansion of orphan crops occur within the 'cereals and pulses' category (i.e., its own category). Within the rural households, the increase in the orphan crops, bring an increase in maize and pulses and nuts. All the other food categories showed a decrease.

Table 3: Percentage changes in the diet composition due to increases in orphan crops by socioeconomic group

	Rural				Urban - less affluent				Urban - more affluent			
	Baseline 1/	Simulations 2/			Baseline 1/	Simulations 2/			Baseline 1/	Simulations 2/		
		2 times	3 times	4 times		2 times	3 times	4 times		2 times	3 times	4 times
Orphan crop	0.153	100.00	199.99	300.00	0.057	100.00	200.00	299.99	0.059	100.00	200.00	300.01
Rice	0.368	-5.34	-10.67	-3.87	0.430	-3.30	-4.36	-4.89	0.655	-1.49	-2.98	-4.47
Maize	2.276	0.50	1.00	0.38	1.365	0.82	1.09	1.23	1.012	-0.95	-1.90	-2.85
Wheat	0.143	-6.01	-12.03	-4.35	0.142	-3.13	-4.14	-4.65	0.188	-1.92	-3.84	-5.75
Fortified flour	0.307	-7.03	-14.05	-5.06	0.407	-2.28	-3.03	-3.40	0.683	1.86	3.72	5.58
Breakfast cereals	0.001	-57.14	-100.00	-55.96	0.000	-68.62	62.34	196.72	0.011	-13.05	-26.11	-39.16
Pulses and nuts	0.581	0.77	1.54	0.57	0.318	-1.47	-1.97	-2.22	0.391	2.47	4.94	7.41
Bread and cakes	0.227	-4.73	-9.47	-3.45	0.344	-2.74	-3.63	-4.09	0.815	-1.84	-3.68	-5.52
Pasta	0.009	-30.99	-61.97	-22.88	0.020	-1.75	-2.33	-2.63	0.059	0.39	0.78	1.17
Meat	0.228	-0.02	-0.05	-0.18	0.181	0.13	0.09	0.01	0.606	0.01	0.01	0.02
Fish and seafood	0.083	-0.02	-0.04	-0.15	0.069	0.19	0.14	0.03	0.122	0.01	0.01	0.02
Milk, cheese and eggs	1.758	-0.02	-0.03	-0.11	1.241	0.13	0.09	0.01	2.289	0.00	0.00	0.01
Oils and fats	0.168	-0.01	-0.02	-0.09	0.188	0.09	0.06	0.01	0.299	0.00	0.01	0.01
Fruits	0.900	-0.02	-0.03	-0.12	0.742	0.10	0.07	0.01	1.792	0.00	0.01	0.01
All vegetables	2.872	-0.02	-0.03	-0.12	2.196	0.12	0.09	0.01	3.787	0.00	0.00	0.01
Sugary products	0.631	-0.01	-0.03	-0.09	0.394	0.07	0.05	0.00	0.449	0.00	0.00	0.00
Spices and miscellaneous	0.052	-0.01	-0.02	-0.06	0.045	0.06	0.04	0.00	0.074	0.00	0.01	0.01
Coffee, tea and cocoa	0.024	-0.02	-0.03	-0.11	0.024	0.08	0.06	0.01	0.044	0.00	0.01	0.01
Soft drinks and juices	0.113	-0.03	-0.06	-0.23	0.127	0.24	0.18	0.04	0.912	0.01	0.02	0.02
P_0 and ΔP on the orphan crop 2/	30.05	-10.32	-20.64	-30.97	24.10	-3.00	-4.00	-4.50	29.96	-7.69	-15.39	-23.08

Note 1/ Units in kg or lts; 2/ Changes (%) with respect to the baseline except for prices.

Table 4: Percentage change in nutrients due to increases in orphan crops by socioeconomic group

	Rural				Urban - less affluent				Urban - more affluent			
	Baseline 1/	Simulations 2/			Baseline 1/	Simulations 2/			Baseline 1/	Simulations 2/		
		2 times	3 times	4 times		2 times	3 times	4 times		2 times	3 times	4 times
Energy (kcal)	2360.82	1.69	3.37	6.06	1828.07	0.63	1.52	2.47	2921.79	0.30	0.59	0.89
Protein (g)	67.93	2.46	4.92	8.17	49.95	1.01	2.29	3.62	87.69	0.69	1.38	2.07
Lipid total (g)	62.71	1.31	2.61	4.56	55.92	0.33	0.86	1.43	98.62	0.19	0.37	0.56
Carbohydrate (g)	350.03	1.57	3.14	5.99	258.96	0.62	1.56	2.56	378.81	0.22	0.44	0.66
Fibre (g)	59.23	3.19	6.39	9.72	41.03	1.66	3.38	5.11	57.35	1.14	2.28	3.43
Calcium (g)	1074.43	3.22	6.45	10.05	794.37	1.61	3.24	4.88	1422.85	0.99	1.97	2.96
Iron (mg)	28.60	4.91	9.83	15.18	21.01	2.40	4.93	7.48	35.97	1.48	2.96	4.44
Zinc (mg)	12.59	2.61	5.22	8.33	8.90	1.26	2.66	4.10	14.12	0.82	1.63	2.45
Magnesium (mg)	479.68	5.28	10.56	16.22	334.81	2.64	5.46	8.32	506.71	1.93	3.85	5.78
Phosphorus (mg)	1650.31	2.84	5.68	9.06	1185.57	1.35	2.86	4.40	1922.71	0.83	1.66	2.49
Potassium (mg)	3812.10	2.25	4.51	6.91	2813.32	1.07	2.18	3.29	4879.13	0.69	1.38	2.08
Sodium (mg)	901.82	-0.53	-1.06	-0.17	780.94	-0.50	-0.58	-0.59	1601.54	-0.48	-0.95	-1.43
Selenium (mcg)	64.06	4.11	8.23	14.10	48.21	1.73	3.95	6.28	86.91	1.03	2.05	3.08
Vitamin C (mg)	169.15	1.28	2.57	3.78	129.45	0.72	1.32	1.88	238.95	0.37	0.74	1.12
Thiamin - Vitamin B1 - (mg)	1.69	2.33	4.65	7.60	1.23	1.01	2.27	3.57	1.92	0.67	1.35	2.02
Riboflavin - Vitamin B2 - (mg)	1.85	1.11	2.22	3.93	1.38	0.51	1.14	1.78	2.55	0.28	0.56	0.85
Niacin - Vitamin B3 - (mg)	13.23	2.57	5.14	8.75	10.13	1.06	2.44	3.88	17.61	0.58	1.15	1.73
Vitamin A - (µg retinol equivalent)	2459.53	0.60	1.20	1.81	2177.80	0.35	0.58	0.79	4720.73	0.11	0.23	0.34
Folate (µg dietary folate equivalence)	523.75	2.80	5.61	8.62	373.44	1.29	2.75	4.23	597.42	1.01	2.02	3.04
Vitamin B12 (µg retinol equivalent)	5.07	-0.18	-0.36	-0.27	4.03	-0.01	-0.10	-0.20	10.91	-0.04	-0.09	-0.13
MAR_0 and ΔMAR 2/	92.03	0.16	0.32	0.55	85.41	0.28	0.58	0.90	96.96	-0.03	-0.07	-0.10

Note 1/ Units in kg or lts; 2/ Changes (%) with respect to the baseline except for the MAR.

Urban households had a response quite different to the rural households, being the most important one of these, the positive response of the non-cereal and pulses response. This is, of course, due to the different set of elasticities.

In the case of the less affluent urban households, they show, like rural households, an increase on the presence of maize on the diet as more orphan crops are included. Another change is the increase in breakfast cereals (although the quantities are very small). All the other products within cereals and pulses show a decrease in their quantities.

The most affluent urban households show quite a different response than the other two socioeconomic groups. In contrast with the other two groups, the quantity of maize on the diet is reduced. However, there is an increase in fortified flour, pulses and nuts and pasta. All the other foods within the cereal and pulses categories show a decrease with respect to the baseline.

Table 4 shows that in contrast with the observed food choice responses, the nutritional results are qualitatively very similar amongst all the socioeconomic groups. All the three groups show a decrease in sodium and a decrease in vitamin B12; otherwise, all the other nutrients show an increase. It is important to note that these results are not only because the increase quantity of orphan crops on the diet but also the changes in the other products.

Whilst the reduction of sodium is welcomed, the small decrease in vitamin B12 can potentially cause severe and irreversible damage, especially to the brain and nervous system (WHO, 2005).

As pointed out in WHO (2005), at levels only slightly lower than normal, people, especially in people over age 60, may feel a range of symptoms such as fatigue, difficulty walking, depression, poor memory, breathlessness, headaches among others. Moreover, the main type of vitamin B12 deficiency anemia is pernicious anemia.

The aggregated indicator of nutrition adequacy (MAR) indicates that for the rural and less affluent urban group the MAR benefit with the increase of the orphan crop on the diet; whilst in the case of the more affluent group the effect is just the opposite. This indicates that the increase of orphan crop on the diet has a particular effect on poorer groups. In addition, since the more affluent urban group is the one most affected by issues of diet westernisation, it would pay to do further research about how orphan crops consumption can replace ultra-processed foods (Monteiro et al., 2010).

V. Conclusions

The purpose of this paper has been to assess the potential impact, in terms of food choices and nutrition, of increasing the consumption of orphan crops (e.g., millet) on the Kenyan diet. This was done using a microeconomic-based methodology, which augments the original consumer problem with a constraint regarding the amount of the orphan crop on the diet.

This is important because there is increasing interest to promote research to improve orphan crops productivity and resilience to environmental shocks; whilst its impact on consumers' nutrition has, however, been analysed only considering the crops individual characteristics and not in the context of the diet.

The overall results indicate that given the current preferences (as measured by the demand elasticities) increase of orphan crops in the diet require a significant decrease in their prices. If this is possible, the inclusion of more orphan crops improves the nutritional situation of the rural and less affluent households (as measured by the MAR); and worsens the situation of the most affluent households.

The results also indicate that if the role of orphan crops are to be expanded, there is the need to develop not just the supply in isolation but also (in parallel) the demand for those crops because the gains in productivity, which will reduce the cost of production and price need to be compensated by a significant demand.

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VII. Annex – Elasticities by socioeconomic group

Rural - Cereal and pulses categories elasticities

	Marshallian elasticities																		Expenditure elasticities	P-value
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value		
Orphan crops	-2.9113	0.0000	0.0172	0.0006	-0.0314	0.0000	0.0412	0.0000	0.2228	0.0000	0.8560	0.0000	-0.0425	0.0000	0.0228	0.1933	0.6120	0.0000	0.1000	0.0000
Rice	0.1535	0.0000	-0.8550	0.0000	0.0901	0.0000	-0.0656	0.0000	0.0646	0.0000	0.3597	0.0000	-0.0536	0.0000	0.0185	0.0587	-0.2820	0.0000	0.0904	0.0000
Maize	-0.0149	0.1527	0.0723	0.0000	-0.1830	0.0000	0.0341	0.0000	0.2218	0.0000	0.0554	0.0030	-0.0286	0.0000	-0.0225	0.0003	0.2146	0.0000	0.0166	0.0000
Wheat	0.1735	0.0000	-0.1139	0.0000	0.0455	0.0000	-4.5755	0.0000	0.1468	0.0000	3.9885	0.0000	-0.0496	0.0000	0.0416	0.0081	-0.4394	0.0000	0.0763	0.0000
Fortified flours	0.2028	0.0000	0.0013	0.6378	0.0464	0.0000	0.0327	0.0000	-1.8057	0.0000	0.5990	0.0000	-0.0084	0.0159	-0.0632	0.0000	0.2359	0.0000	0.0821	0.0000
Breakfast cereals	1.6519	0.0000	0.0504	0.0874	-0.0994	0.0000	1.5652	0.0000	1.2700	0.0000	-11.8910	0.0000	-0.2129	0.0000	-0.4383	0.0000	3.4065	0.0000	0.5258	0.0000
Pulses and nuts	-0.0240	0.1946	-0.0340	0.0000	-0.0467	0.0000	-0.0062	0.2106	0.0492	0.0002	-0.0076	0.8235	-0.3849	0.0000	-0.0202	0.0310	0.3801	0.0000	0.0807	0.0000
Bread and cakes	0.1351	0.0000	0.0022	0.3822	-0.0352	0.0000	0.0351	0.0000	-0.0045	0.7201	0.1426	0.0011	-0.0217	0.0000	-0.8190	0.0000	0.2800	0.0000	0.1315	0.0000
Pasta	0.8881	0.0000	-0.1267	0.0000	-0.0822	0.0000	0.0354	0.0002	0.4012	0.0000	2.6874	0.0000	-0.0286	0.0086	-0.0578	0.0522	-8.1249	0.0000	0.6764	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Rural - Cereal and pulses categories elasticities

	Hicksian elasticities																	
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value
Orphan crops	-2.9104	0.0000	0.0201	0.0001	-0.0232	0.0000	0.0421	0.0000	0.2246	0.0000	0.8560	0.0000	-0.0384	0.0000	0.0249	0.1553	0.6122	0.0000
Rice	0.1543	0.0000	-0.8524	0.0000	0.0976	0.0000	-0.0648	0.0000	0.0662	0.0000	0.3597	0.0000	-0.0499	0.0000	0.0204	0.0375	-0.2819	0.0000
Maize	-0.0147	0.1569	0.0728	0.0000	-0.1816	0.0000	0.0343	0.0000	0.2221	0.0000	0.0554	0.0030	-0.0279	0.0000	-0.0221	0.0004	0.2146	0.0000
Wheat	0.1741	0.0000	-0.1117	0.0000	0.0518	0.0000	-4.5748	0.0000	0.1482	0.0000	3.9885	0.0000	-0.0464	0.0000	0.0432	0.0060	-0.4393	0.0000
Fortified flour	0.2035	0.0000	0.0037	0.1781	0.0532	0.0000	0.0334	0.0000	-1.8042	0.0000	0.5991	0.0000	-0.0049	0.1520	-0.0615	0.0000	0.2360	0.0000
Breakfast cereals	1.6566	0.0000	0.0659	0.0260	-0.0559	0.0002	1.5699	0.0000	1.2790	0.0000	-11.8910	0.0000	-0.1909	0.0000	-0.4275	0.0000	3.4073	0.0000
Pulses and nuts	-0.0232	0.2084	-0.0317	0.0000	-0.0400	0.0000	-0.0055	0.2681	0.0506	0.0001	-0.0075	0.8240	-0.3815	0.0000	-0.0185	0.0478	0.3802	0.0000
Bread and cakes	0.1363	0.0000	0.0060	0.0144	-0.0243	0.0000	0.0363	0.0000	-0.0022	0.8597	0.1426	0.0011	-0.0162	0.0000	-0.8163	0.0000	0.2802	0.0000
Pasta	0.8941	0.0000	-0.1068	0.0000	-0.0262	0.0000	0.0414	0.0000	0.4129	0.0000	2.6875	0.0000	-0.0003	0.9810	-0.0438	0.1407	-8.1238	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Rural - Food categories elasticities

	Marshallian elasticities																						Expenditure elasticities	P-value
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value		
Cereals and pulses	-0.1913	0.0000	-0.0236	0.0085	-0.0235	0.0322	-0.0079	0.0063	-0.0015	0.5483	-0.0348	0.0000	-0.0470	0.0000	-0.0028	0.2889	-0.0011	0.0601	-0.0010	0.6864	-0.0092	0.4719	0.0485	0.0000
Meat	-0.0403	0.0000	-1.4204	0.0000	0.1444	0.0000	-0.0343	0.0004	-0.0124	0.0000	0.0469	0.0071	0.0426	0.0001	-0.0025	0.6028	-0.0004	0.1584	-0.0002	0.9176	0.0397	0.3124	0.1294	0.0000
Fish and seafood	-0.0641	0.0000	0.1151	0.0032	-2.3054	0.0000	0.0757	0.0000	-0.0219	0.0000	-0.0807	0.0015	0.0414	0.0186	-0.0188	0.1883	0.0003	0.5436	0.0090	0.0008	-0.0837	0.1499	0.1073	0.0000
Milk, cheese and eggs	-0.0083	0.0000	0.0230	0.0046	0.1055	0.0000	-0.1860	0.0000	-0.0016	0.0005	0.0163	0.0165	-0.0414	0.0000	-0.0087	0.0000	-0.0001	0.1306	-0.0008	0.0359	0.0553	0.0004	0.0743	0.0000
Oils and fats	-0.0129	0.3386	-0.0790	0.0000	-0.0840	0.0000	-0.0220	0.0000	-0.2138	0.0000	-0.0075	0.3714	0.0354	0.0000	-0.0121	0.0124	-0.0016	0.2130	0.0105	0.0940	-0.1547	0.0000	0.0600	0.0000
Fruits	-0.0221	0.0000	0.0358	0.0000	0.0295	0.0002	-0.0202	0.0000	-0.0020	0.0000	-0.5118	0.0000	-0.0731	0.0000	-0.0112	0.0000	-0.0005	0.0000	-0.0011	0.0015	-0.0487	0.0028	0.0828	0.0000
All vegetables	-0.0293	0.0000	0.0730	0.0000	0.0885	0.0000	-0.0523	0.0000	0.0023	0.0000	-0.0934	0.0000	-0.1742	0.0000	-0.0011	0.3902	-0.0006	0.0000	0.0005	0.1311	0.0998	0.0000	0.0863	0.0000
Sugary products	-0.0093	0.0851	0.0373	0.0295	0.0150	0.6711	-0.0381	0.0000	-0.0043	0.0220	-0.0441	0.0000	0.0082	0.1469	-0.1342	0.0000	-0.0008	0.0231	0.0002	0.8974	-0.0197	0.4505	0.0653	0.0000
Spices and miscellaneous	-0.0370	0.0656	0.0191	0.2924	0.0602	0.0065	0.0031	0.5691	-0.0094	0.2609	-0.0153	0.1138	-0.0286	0.0000	-0.0105	0.0590	-0.0673	0.0000	-0.0225	0.0394	-0.1204	0.0000	0.0418	0.0000
Coffee, tea and cocoa	-0.0240	0.5178	0.0267	0.4853	0.2092	0.0000	-0.0402	0.0004	0.0283	0.1024	-0.0421	0.0283	0.0141	0.2363	-0.0016	0.8883	-0.0100	0.0340	-0.3210	0.0000	-0.1073	0.0361	0.0748	0.0000
Soft drinks and juices	-0.0321	0.0000	0.0591	0.0604	0.0583	0.0694	-0.0051	0.7133	-0.0164	0.0000	-0.0950	0.0010	0.0589	0.0001	-0.0167	0.0033	-0.0024	0.0000	-0.0041	0.0111	-3.7888	0.0000	0.1642	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Rural - Food categories elasticities

	Hicksian elasticities																					
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value
Cereals and pulses	-0.1810	0.0000	-0.0204	0.0233	-0.0227	0.0384	-0.0036	0.2161	-0.0003	0.9173	-0.0332	0.0000	-0.0430	0.0000	-0.0007	0.7934	-0.0010	0.1072	-0.0006	0.8300	-0.0088	0.4889
Meat	-0.0129	0.0129	-1.4116	0.0000	0.1465	0.0000	-0.0227	0.0173	-0.0090	0.0000	0.0512	0.0033	0.0534	0.0000	0.0030	0.5230	0.0000	0.9868	0.0011	0.4537	0.0406	0.3012
Fish and seafood	-0.0414	0.0000	0.1223	0.0017	-2.3037	0.0000	0.0853	0.0000	-0.0191	0.0000	-0.0772	0.0024	0.0503	0.0041	-0.0142	0.3206	0.0007	0.2149	0.0101	0.0002	-0.0829	0.1537
Milk, cheese and eggs	0.0074	0.0000	0.0280	0.0006	0.1067	0.0000	-0.1794	0.0000	0.0004	0.4187	0.0187	0.0056	-0.0352	0.0000	-0.0055	0.0000	0.0001	0.1145	0.0000	0.8968	0.0558	0.0003
Oils and fats	-0.0002	0.9904	-0.0750	0.0000	-0.0830	0.0000	-0.0167	0.0004	-0.2122	0.0000	-0.0055	0.5106	0.0404	0.0000	-0.0096	0.0482	-0.0014	0.2749	0.0111	0.0768	-0.1543	0.0000
Fruits	-0.0046	0.0003	0.0414	0.0000	0.0308	0.0001	-0.0128	0.0016	0.0001	0.7195	-0.5090	0.0000	-0.0663	0.0000	-0.0077	0.0000	-0.0002	0.0010	-0.0003	0.4169	-0.0481	0.0032
All vegetables	-0.0110	0.0000	0.0788	0.0000	0.0899	0.0000	-0.0446	0.0000	0.0046	0.0000	-0.0906	0.0000	-0.1670	0.0000	0.0026	0.0408	-0.0004	0.0000	0.0014	0.0001	0.1004	0.0000
Sugary products	0.0045	0.3974	0.0417	0.0150	0.0161	0.6497	-0.0323	0.0000	-0.0026	0.1650	-0.0419	0.0000	0.0136	0.0149	-0.1314	0.0000	-0.0005	0.1044	0.0009	0.5970	-0.0192	0.4614
Spices and miscellaneous	-0.0282	0.1624	0.0219	0.2276	0.0609	0.0059	0.0068	0.2042	-0.0083	0.3206	-0.0139	0.1500	-0.0252	0.0000	-0.0087	0.1175	-0.0672	0.0000	-0.0220	0.0432	-0.1201	0.0000
Coffee, tea and cocoa	-0.0082	0.8260	0.0318	0.4073	0.2104	0.0000	-0.0335	0.0027	0.0303	0.0809	-0.0397	0.0388	0.0203	0.0843	0.0016	0.8918	-0.0097	0.0388	-0.3202	0.0000	-0.1067	0.0371
Soft drinks and juices	0.0027	0.6568	0.0701	0.0260	0.0609	0.0580	0.0096	0.4792	-0.0122	0.0000	-0.0896	0.0019	0.0725	0.0000	-0.0097	0.0862	-0.0018	0.0000	-0.0025	0.1245	-3.7876	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban less affluent - Cereal categories elasticities

	Marshallian elasticities																		Expenditure elasticities	P-value
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value		
Orphan crops	-4.0206	0.0000	0.0061	0.3259	-0.1115	0.0000	0.0325	0.0000	0.1044	0.0000	1.1602	0.0000	-0.0479	0.0006	0.0426	0.1697	0.2712	0.0000	0.4034	0.0000
Rice	0.2737	0.0000	-0.9009	0.0000	0.0561	0.0000	-0.0575	0.0000	0.0797	0.0000	0.4226	0.0000	-0.0532	0.0000	0.0129	0.1788	-0.2042	0.0000	0.2804	0.0000
Maize	-0.0653	0.0002	0.0403	0.0000	-0.3532	0.0000	0.0030	0.0360	0.2988	0.0000	0.2537	0.0000	-0.0640	0.0000	0.0224	0.0061	0.3564	0.0000	0.0622	0.0000
Wheat	0.2592	0.0000	-0.0994	0.0000	-0.0687	0.0000	-4.2698	0.0000	0.1602	0.0000	2.6054	0.0000	-0.0437	0.0000	0.0084	0.5564	-0.0327	0.3473	0.4102	0.0000
Fortified flours	0.1876	0.0000	0.0064	0.0278	0.1333	0.0000	0.0403	0.0000	-1.4520	0.0000	0.4417	0.0000	-0.0067	0.2490	-0.0206	0.1192	0.1886	0.0000	0.1769	0.0000
Breakfast cereals	4.8339	0.0000	-0.2325	0.0000	-0.7616	0.0000	1.3250	0.0000	0.8461	0.0000	-31.4200	0.0000	-0.4762	0.0000	-0.2111	0.0042	7.8144	0.0000	5.9631	0.0000
Pulses and nuts	0.1200	0.0002	-0.0250	0.0000	-0.1087	0.0000	0.0146	0.0000	0.0374	0.0003	0.4114	0.0000	-0.5722	0.0000	0.0340	0.0026	0.2224	0.0000	0.2678	0.0000
Bread and cakes	0.2260	0.0000	-0.0163	0.0000	-0.0587	0.0000	0.0255	0.0000	0.0195	0.0000	0.4619	0.0000	-0.0307	0.0000	-0.6696	0.0000	0.2946	0.0000	0.3870	0.0000
Pasta	0.1431	0.0080	-0.0808	0.0000	0.0912	0.0000	-0.0340	0.0000	0.0716	0.0002	1.7459	0.0000	-0.0066	0.5625	0.0992	0.0000	-3.4244	0.0000	0.2552	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban less affluent - Cereal categories elasticities

	Hicksian elasticities																	
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value
Orphan crops	-4.0187	0.0000	0.0187	0.0009	-0.0898	0.0000	0.0358	0.0000	0.1115	0.0000	1.1603	0.0000	-0.0371	0.0056	0.0537	0.0782	0.2727	0.0000
Rice	0.2750	0.0000	-0.8922	0.0000	0.0711	0.0000	-0.0553	0.0000	0.0847	0.0000	0.4227	0.0000	-0.0456	0.0000	0.0206	0.0304	-0.2032	0.0000
Maize	-0.0650	0.0002	0.0422	0.0000	-0.3499	0.0000	0.0035	0.0175	0.2999	0.0000	0.2537	0.0000	-0.0623	0.0000	0.0241	0.0027	0.3566	0.0000
Wheat	0.2611	0.0000	-0.0866	0.0000	-0.0466	0.0000	-4.2665	0.0000	0.1675	0.0000	2.6055	0.0000	-0.0326	0.0000	0.0197	0.1656	-0.0312	0.3692
Fortified flour	0.1884	0.0000	0.0119	0.0000	0.1428	0.0000	0.0417	0.0000	-1.4488	0.0000	0.4417	0.0000	-0.0019	0.7281	-0.0158	0.2276	0.1892	0.0000
Breakfast cereals	4.8618	0.0000	-0.0458	0.0341	-0.4409	0.0000	1.3726	0.0000	0.9522	0.0000	-31.4190	0.0000	-0.3155	0.0000	-0.0475	0.5159	7.8353	0.0000
Pulses and nuts	0.1213	0.0001	-0.0166	0.0000	-0.0943	0.0000	0.0167	0.0000	0.0421	0.0001	0.4115	0.0000	-0.5650	0.0000	0.0413	0.0002	0.2233	0.0000
Bread and cakes	0.2278	0.0000	-0.0042	0.0000	-0.0379	0.0000	0.0286	0.0000	0.0264	0.0000	0.4620	0.0000	-0.0202	0.0000	-0.6590	0.0000	0.2959	0.0000
Pasta	0.1443	0.0075	-0.0728	0.0000	0.1049	0.0000	-0.0320	0.0000	0.0761	0.0001	1.7459	0.0000	0.0003	0.9803	0.1062	0.0000	-3.4236	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban less affluent - Food categories elasticities

	Marshallian elasticities																						Expenditure elasticities	P-value
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value		
Cereals and pulses	-0.1688	0.0000	0.0279	0.0001	0.0543	0.0000	-0.0423	0.0000	-0.0098	0.0000	-0.0141	0.0009	-0.0283	0.0000	-0.0460	0.0000	-0.0026	0.0000	-0.0061	0.0014	0.2307	0.0000	0.3423	0.0000
Meat	-0.1043	0.0000	-1.0459	0.0000	0.1269	0.0000	-0.0781	0.0000	-0.0290	0.0000	0.0059	0.5055	-0.0258	0.0000	-0.0550	0.0000	-0.0029	0.0000	-0.0067	0.0166	0.3474	0.0000	0.5929	0.0000
Fish and seafood	-0.1836	0.0000	0.0380	0.0578	-1.9630	0.0000	-0.0244	0.0579	-0.0241	0.0000	-0.0503	0.0001	-0.0329	0.0001	-0.0864	0.0000	-0.0041	0.0000	-0.0017	0.6629	0.5386	0.0000	0.8365	0.0000
Milk, cheese and eggs	-0.1015	0.0000	0.0555	0.0000	0.2140	0.0000	-0.2575	0.0000	-0.0129	0.0000	-0.0329	0.0000	-0.0592	0.0000	-0.0795	0.0000	-0.0027	0.0000	-0.0064	0.0000	0.3363	0.0000	0.6050	0.0000
Oils and fats	-0.0835	0.0000	-0.0692	0.0000	0.0745	0.0002	-0.0501	0.0000	-0.2997	0.0000	0.0106	0.1794	0.0319	0.0000	-0.0423	0.0000	-0.0115	0.0000	-0.0006	0.9369	0.1213	0.0000	0.4026	0.0000
Fruits	-0.0779	0.0000	0.0686	0.0000	0.1040	0.0000	-0.0783	0.0000	-0.0059	0.0002	-0.4300	0.0000	-0.0752	0.0000	-0.0351	0.0000	-0.0020	0.0000	-0.0034	0.0499	0.2307	0.0000	0.4475	0.0000
All vegetables	-0.1022	0.0000	0.0803	0.0000	0.1995	0.0000	-0.1186	0.0000	0.0031	0.0821	-0.0904	0.0000	-0.2193	0.0000	-0.0582	0.0000	-0.0027	0.0000	0.0109	0.0002	0.3760	0.0000	0.5669	0.0000
Sugary products	-0.0670	0.0000	0.0470	0.0000	0.1056	0.0000	-0.0673	0.0000	-0.0068	0.0000	0.0067	0.2178	-0.0203	0.0000	-0.1154	0.0000	-0.0017	0.0000	-0.0062	0.0000	0.2218	0.0000	0.3456	0.0000
Spices and miscellaneous	-0.0799	0.0000	0.0283	0.1197	0.0793	0.0009	-0.0168	0.0488	-0.0604	0.0000	-0.0004	0.9676	-0.0152	0.2015	-0.0289	0.0000	-0.1123	0.0000	-0.0294	0.0072	0.0483	0.1138	0.2719	0.0000
Coffee, tea and cocoa	-0.0950	0.0000	0.0224	0.4735	0.1743	0.0000	-0.0602	0.0001	-0.0022	0.8776	-0.0022	0.8989	0.0901	0.0000	-0.0702	0.0000	-0.0102	0.0028	-0.2619	0.0000	0.2663	0.0000	0.3720	0.0000
Soft drinks and juices	-0.1325	0.0000	0.1559	0.0000	0.4034	0.0000	-0.0624	0.0000	-0.0290	0.0000	-0.0167	0.1145	-0.0278	0.0000	-0.0851	0.0000	-0.0066	0.0000	-0.0047	0.1498	-2.7955	0.0000	1.0781	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban less affluent - Food categories elasticities

	Hicksian elasticities																					
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value
Cereals and pulses	-0.1094	0.0000	0.0446	0.0000	0.0607	0.0000	-0.0173	0.0000	-0.0014	0.3992	-0.0041	0.3373	-0.0018	0.5585	-0.0344	0.0000	-0.0016	0.0000	-0.0030	0.1159	0.2333	0.0000
Meat	-0.0014	0.8338	-1.0170	0.0000	0.1380	0.0000	-0.0349	0.0001	-0.0145	0.0000	0.0232	0.0087	0.0201	0.0000	-0.0350	0.0000	-0.0011	0.0348	-0.0014	0.6233	0.3521	0.0000
Fish and seafood	-0.0384	0.0001	0.0788	0.0001	-1.9473	0.0000	0.0367	0.0017	-0.0035	0.2810	-0.0258	0.0456	0.0319	0.0000	-0.0582	0.0000	-0.0015	0.0286	0.0059	0.1278	0.5452	0.0000
Milk, cheese and eggs	0.0036	0.2533	0.0850	0.0000	0.2253	0.0000	-0.2134	0.0000	0.0020	0.0337	-0.0152	0.0005	-0.0123	0.0000	-0.0590	0.0000	-0.0009	0.0000	-0.0009	0.4149	0.3410	0.0000
Oils and fats	-0.0136	0.1714	-0.0495	0.0010	0.0820	0.0000	-0.0207	0.0022	-0.2898	0.0000	0.0224	0.0046	0.0631	0.0000	-0.0287	0.0000	-0.0102	0.0000	0.0030	0.6967	0.1245	0.0000
Fruits	-0.0003	0.9540	0.0904	0.0000	0.1124	0.0000	-0.0457	0.0000	0.0051	0.0002	-0.4169	0.0000	-0.0406	0.0000	-0.0200	0.0000	-0.0006	0.0384	0.0007	0.6935	0.2342	0.0000
All vegetables	-0.0038	0.4480	0.1079	0.0000	0.2102	0.0000	-0.0772	0.0000	0.0170	0.0000	-0.0738	0.0000	-0.1753	0.0000	-0.0390	0.0000	-0.0009	0.0951	0.0160	0.0000	0.3804	0.0000
Sugary products	-0.0070	0.0226	0.0638	0.0000	0.1120	0.0000	-0.0421	0.0000	0.0016	0.1202	0.0168	0.0015	0.0065	0.0020	-0.1037	0.0000	-0.0006	0.0073	-0.0031	0.0149	0.2245	0.0000
Spices and miscellaneous	-0.0327	0.0152	0.0415	0.0234	0.0844	0.0004	0.0030	0.7051	-0.0538	0.0001	0.0076	0.4464	0.0059	0.6252	-0.0197	0.0026	-0.1115	0.0000	-0.0269	0.0138	0.0504	0.0996
Coffee, tea and cocoa	-0.0304	0.1445	0.0405	0.1979	0.1813	0.0000	-0.0331	0.0162	0.0070	0.6194	0.0087	0.6184	0.1189	0.0000	-0.0576	0.0000	-0.0091	0.0078	-0.2585	0.0000	0.2692	0.0000
Soft drinks and juices	0.0546	0.0000	0.2084	0.0000	0.4236	0.0000	0.0162	0.1824	-0.0025	0.3379	0.0149	0.1406	0.0557	0.0000	-0.0487	0.0000	-0.0033	0.0000	0.0050	0.1225	-2.7871	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban more affluent - Cereal categories elasticities

	Marshallian elasticities																		Expenditure	P-value
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value	elasticities	
Orphan crops	-3.8937	0.0000	-0.0380	0.4281	-0.1403	0.0137	0.0145	0.0922	-0.0333	0.0375	0.4316	0.0021	-0.0799	0.0011	-0.0078	0.6408	-0.0168	0.6256	0.3942	0.0000
Rice	0.0575	0.0073	-0.3442	0.0000	0.0248	0.0432	0.0016	0.2509	0.0053	0.0111	0.0339	0.2596	0.0003	0.9308	-0.0023	0.2991	-0.0006	0.9121	0.0944	0.0000
Maize	0.0366	0.0433	0.0260	0.0112	-0.6087	0.0000	0.0019	0.1083	0.0216	0.0000	0.0813	0.0001	-0.0140	0.0000	0.0093	0.1510	0.0115	0.0007	0.0797	0.0017
Wheat	0.0740	0.2621	-0.0474	0.0309	-0.0641	0.0099	-3.7169	0.0000	0.1690	0.0000	0.6241	0.0000	-0.0669	0.0002	0.0844	0.0000	-0.0308	0.3872	0.1311	0.0002
Fortified flours	-0.0726	0.1359	0.0267	0.0439	0.1899	0.0000	0.0684	0.0000	-1.0177	0.0000	0.3197	0.0000	-0.1099	0.0000	-0.0483	0.0000	0.1360	0.0000	0.0543	0.0097
Breakfast cereals	0.5066	0.0200	-0.0924	0.3635	0.1036	0.2891	0.1225	0.0000	0.1496	0.0000	-6.2150	0.0000	0.1304	0.0107	-0.1239	0.0002	0.4834	0.0000	0.2944	0.0389
Pulses and nuts	-0.0967	0.0676	-0.0112	0.4734	-0.1307	0.0000	-0.0141	0.0062	-0.0790	0.0000	0.2563	0.0002	-0.6079	0.0000	0.0386	0.0000	-0.0219	0.3683	0.1292	0.0000
Bread and cakes	0.0711	0.0806	-0.0046	0.6458	0.0738	0.1902	0.0337	0.0000	-0.0397	0.0000	-0.1386	0.0137	0.0510	0.0000	-0.3588	0.0000	0.0890	0.0000	0.0948	0.0000
Pasta	-0.0165	0.8519	-0.0995	0.0016	-0.0620	0.0410	-0.0058	0.6188	0.1105	0.0000	0.8853	0.0000	-0.0459	0.1050	0.0666	0.0002	-3.5836	0.0000	0.2664	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban more affluent - Cereal categories elasticities

	Hicksian elasticities																	
	Orphan crops	P-value	Rice	P-value	Maize	P-value	Wheat	P-value	Fortified flours	P-value	Breakfast cereals	P-value	Pulses and nuts	P-value	Bread and cakes	P-value	Pasta	P-value
Orphan crops	-3.8929	0.0000	-0.0306	0.5192	-0.1345	0.0171	0.0158	0.0682	-0.0287	0.0721	0.4320	0.0021	-0.0742	0.0023	0.0028	0.8625	-0.0159	0.6444
Rice	0.0577	0.0071	-0.3424	0.0000	0.0262	0.0314	0.0019	0.1741	0.0064	0.0022	0.0340	0.2583	0.0017	0.6169	0.0002	0.9046	-0.0004	0.9427
Maize	0.0367	0.0426	0.0275	0.0058	-0.6076	0.0000	0.0021	0.0772	0.0225	0.0000	0.0813	0.0001	-0.0128	0.0000	0.0114	0.0731	0.0117	0.0006
Wheat	0.0742	0.2605	-0.0449	0.0391	-0.0622	0.0117	-3.7165	0.0000	0.1705	0.0000	0.6243	0.0000	-0.0650	0.0002	0.0879	0.0000	-0.0305	0.3918
Fortified flour	-0.0725	0.1365	0.0277	0.0354	0.1907	0.0000	0.0685	0.0000	-1.0171	0.0000	0.3198	0.0000	-0.1091	0.0000	-0.0469	0.0000	0.1361	0.0000
Breakfast cereals	0.5072	0.0199	-0.0869	0.3895	0.1079	0.2641	0.1235	0.0000	0.1530	0.0000	-6.2147	0.0000	0.1347	0.0078	-0.1160	0.0005	0.4841	0.0000
Pulses and nuts	-0.0965	0.0684	-0.0088	0.5721	-0.1288	0.0000	-0.0136	0.0080	-0.0775	0.0000	0.2564	0.0002	-0.6060	0.0000	0.0421	0.0000	-0.0216	0.3748
Bread and cakes	0.0713	0.0799	-0.0028	0.7765	0.0752	0.1817	0.0340	0.0000	-0.0386	0.0000	-0.1385	0.0138	0.0524	0.0000	-0.3563	0.0000	0.0892	0.0000
Pasta	-0.0160	0.8564	-0.0945	0.0026	-0.0581	0.0525	-0.0049	0.6737	0.1136	0.0000	0.8856	0.0000	-0.0420	0.1381	0.0738	0.0000	-3.5830	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban more affluent - Food categories elasticities

	Marshallian elasticities																						Expenditure elasticities	P-value
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value		
Cereals and pulses	-0.1408	0.0000	-0.0221	0.0370	-0.1030	0.0000	-0.0164	0.0110	-0.0095	0.0009	0.0071	0.1341	-0.0047	0.6088	-0.0159	0.0006	-0.0019	0.1034	-0.0051	0.1547	0.0636	0.0000	0.0919	0.0000
Meat	-0.0590	0.0002	-0.7156	0.0000	0.0474	0.0951	-0.0108	0.2951	-0.0055	0.2610	0.0127	0.3261	0.0222	0.1944	0.0041	0.6465	0.0010	0.6479	-0.0066	0.3645	-0.0312	0.1191	0.2398	0.0000
Fish and seafood	-0.1272	0.0000	0.0008	0.9664	-1.8778	0.0000	0.0853	0.0000	-0.0078	0.0372	-0.0663	0.0000	0.0362	0.0002	-0.0342	0.1660	-0.0052	0.0004	0.0053	0.2871	0.0350	0.2895	0.2170	0.0000
Milk, cheese and eggs	-0.0160	0.0090	0.0150	0.0857	0.1378	0.0000	-0.1408	0.0000	0.0009	0.5597	-0.0013	0.8816	-0.0171	0.0000	-0.0015	0.6152	0.0013	0.0182	-0.0012	0.4996	0.0472	0.0000	0.1090	0.0000
Oils and fats	-0.0655	0.0003	-0.0070	0.7599	-0.0061	0.8169	0.0006	0.9518	-0.2999	0.0000	0.0061	0.5286	0.0996	0.0001	-0.0158	0.1485	-0.0192	0.0064	-0.0134	0.2950	0.0076	0.6357	0.1312	0.0000
Fruits	-0.0053	0.5937	0.0299	0.1082	-0.1069	0.0001	-0.0247	0.0902	-0.0001	0.9792	-0.1892	0.0000	-0.0485	0.0000	0.0100	0.0927	-0.0020	0.1160	0.0051	0.2833	-0.0375	0.0177	0.2026	0.0000
All vegetables	-0.0099	0.5114	0.0491	0.0349	0.1236	0.0000	-0.0343	0.0000	0.0280	0.0001	-0.0318	0.0000	-0.2894	0.0000	0.0126	0.0384	0.0004	0.8614	0.0018	0.7839	0.0604	0.0014	0.1031	0.0000
Sugary products	-0.0463	0.0010	0.0315	0.1172	-0.0835	0.3914	0.0007	0.9535	-0.0065	0.2360	0.0256	0.0065	0.0261	0.0264	-0.1796	0.0000	-0.0024	0.2799	0.0265	0.0004	-0.0009	0.9635	0.0658	0.0428
Spices and miscellaneous	-0.0570	0.0235	0.0286	0.3882	-0.0785	0.0352	0.0157	0.2614	-0.0673	0.0053	-0.0189	0.1484	-0.0029	0.9258	-0.0222	0.1430	-0.0898	0.0000	-0.0346	0.0777	-0.0841	0.0003	0.1857	0.0000
Coffee, tea and cocoa	-0.0545	0.0670	-0.0325	0.4648	0.0917	0.0647	-0.0253	0.1955	-0.0192	0.2671	0.0218	0.2232	0.0026	0.9363	0.0664	0.0009	-0.0136	0.0767	-0.3083	0.0000	-0.0420	0.1905	0.1339	0.0108
Soft drinks and juices	0.0054	0.6276	-0.0136	0.4427	0.1127	0.0313	-0.0073	0.4962	-0.0047	0.0402	-0.0230	0.0028	0.0034	0.6776	-0.0146	0.0117	-0.0042	0.0000	-0.0058	0.0826	-0.9083	0.0000	0.3799	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey

Urban more affluent - Food categories elasticities

	Hicksian elasticities																					
	Cereals and pulses	P-value	Meat	P-value	Fish and seafood	P-value	Dairy and eggs	P-value	Oils and fats	P-value	Fruits	P-value	All vegetables	P-value	Sugary products	P-value	Spices and others	P-value	Coffee, tea and cocoa	P-value	Soft drinks and juices	P-value
Cereals and pulses	-0.1321	0.0000	-0.0163	0.1278	-0.1017	0.0000	-0.0113	0.0654	-0.0082	0.0036	0.0098	0.0355	-0.0002	0.9790	-0.0146	0.0018	-0.0017	0.1612	-0.0045	0.2076	0.0653	0.0000
Meat	-0.0362	0.0167	-0.7005	0.0000	0.0507	0.0744	0.0025	0.8081	-0.0020	0.6739	0.0199	0.1274	0.0338	0.0515	0.0075	0.3955	0.0017	0.4290	-0.0051	0.4837	-0.0268	0.1822
Fish and seafood	-0.1066	0.0000	0.0145	0.4805	-1.8748	0.0000	0.0973	0.0000	-0.0047	0.2044	-0.0598	0.0000	0.0467	0.0000	-0.0311	0.2060	-0.0046	0.0019	0.0067	0.1800	0.0390	0.2362
Milk, cheese and eggs	-0.0056	0.3039	0.0218	0.0102	0.1393	0.0000	-0.1347	0.0000	0.0024	0.0874	0.0020	0.8134	-0.0118	0.0018	0.0000	0.9905	0.0016	0.0027	-0.0005	0.7648	0.0492	0.0000
Oils and fats	-0.0531	0.0024	0.0013	0.9550	-0.0043	0.8710	0.0079	0.4350	-0.2981	0.0000	0.0101	0.2901	0.1060	0.0001	-0.0139	0.2058	-0.0188	0.0075	-0.0126	0.3258	0.0100	0.5334
Fruits	0.0140	0.1391	0.0427	0.0235	-0.1041	0.0002	-0.0135	0.3566	0.0028	0.3440	-0.1831	0.0000	-0.0387	0.0000	0.0129	0.0291	-0.0014	0.2667	0.0063	0.1772	-0.0338	0.0317
All vegetables	-0.0001	0.9937	0.0556	0.0140	0.1250	0.0000	-0.0286	0.0001	0.0295	0.0001	-0.0287	0.0000	-0.2844	0.0000	0.0140	0.0195	0.0007	0.7660	0.0025	0.7082	0.0623	0.0011
Sugary products	-0.0401	0.0045	0.0357	0.0780	-0.0826	0.3959	0.0044	0.7046	-0.0055	0.3167	0.0276	0.0028	0.0293	0.0095	-0.1787	0.0000	-0.0022	0.3193	0.0269	0.0004	0.0003	0.9881
Spices and miscellaneous	-0.0394	0.1160	0.0403	0.2249	-0.0760	0.0416	0.0260	0.0522	-0.0646	0.0074	-0.0133	0.3072	0.0061	0.8443	-0.0195	0.1972	-0.0893	0.0000	-0.0334	0.0885	-0.0807	0.0006
Coffee, tea and cocoa	-0.0417	0.1574	-0.0241	0.5922	0.0936	0.0595	-0.0178	0.3357	-0.0173	0.3157	0.0258	0.1551	0.0091	0.7799	0.0683	0.0007	-0.0132	0.0857	-0.3075	0.0000	-0.0395	0.2194
Soft drinks and juices	0.0415	0.0000	0.0103	0.5462	0.1180	0.0241	0.0138	0.1695	0.0007	0.7525	-0.0115	0.1149	0.0218	0.0071	-0.0091	0.1112	-0.0031	0.0009	-0.0034	0.3102	-0.9013	0.0000

Source: Own elaboration based on the Kenya Integrated Household Survey