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From plate to policy: segmenting consumers' food behaviours to tailor nutritional recommendations in African cities

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Abstract

Malnutrition poses significant challenges to African food systems. Addressing these challenges requires synergistic strategies informed by a comprehensive understanding of consumers' food preferences and characteristics, which necessitates the identification of more homogeneous consumer groups. To help reach this objective, this article presents a novel segmentation of African urban food consumers from nine cities across Kenya, Morocco, Tunisia, and Tanzania. The segmentation is based on diet quality indicators and behavioural traits, gathered through structured surveys combined with incentivized in-lab behavioural experiments. Subsequent cluster analyses identified four primary consumer groups characterized by shared behavioural patterns, diet quality, and propensity to food change. These groups serve as the basis for tailored nutritional recommendations aimed at providing policymakers with practical solutions to reinforce the nutritional capacity of local food systems.

Keywords: Behavioural economics, Cluster analysis, Consumer profiles, Food security, Food value chain, Innovation

Introduction and literature review

Poor diets and malnutrition represent some of the most significant societal challenges that global food systems currently confront (Micha and Karageorgou 2022). Globally, in 2022, between 8.5% and 10% of the total world population (690 to 783 million people), experienced food insecurity, making an increase of 122 million individuals compared with pre-COVID-19 pandemic levels (FAO et al. 2023). As urbanization progresses worldwide, food systems are undergoing rapid transformations. Traditional diets are giving way to an increasing consumption of highly processed and unhealthy foods. Currently, about 70% of the food purchases in African urban areas are of processed food

products, with 47% of them being either highly or ultra-processed goods (Reardon et al. 2021). FAO et al (2023) estimates that in 2022, 2.4 billion people did not have access to a sufficient nutrient intake. The prevalence of undernourishment¹ in Africa continued to increase, reaching 19.7% in 2022; and proportionally the highest when compared with other regions of the world. Approximately 342 million people in Africa are severely food insecure, while 527 million are moderately food insecure; 60.9% of the total population.

Tackling the root causes of malnutrition requires profound changes in the way global food value chains are organized and maintained. Policy orchestration, involving all phases of the food value chain is needed to achieve transformative changes in African and global food systems.² This is essential for reaching the nutrition and food security targets pledged by the Sustainable Development Goals (UNEP et al. 2023). The promotion of Nutrition-sensitive value chains (NSVC)³ is thus pivotal to take a more inclusive approach to food system development, which equally weights socio-economic and nutritional outcomes (Allen and de Brauw 2018).

The central question addressed in this article is how to segment and profile African food consumers in order to strengthen local NSVCs and promote tailored nutritional recommendations. From a consumer economic perspective, strengthening the capacity development for NSVCs entails maximizing the consumer utility in light of food availability (which is linked to product prices, consumer income and product accessibility) and factors affecting demand for nutritious foods (e.g. beliefs, habits, emotions, culture and demographic characteristics, Allen and de Brauw 2018; Ventura and Worobey 2013). This indicates that to spur NSVC interventions from the consumer side, systematic knowledge of consumers' food preferences is of paramount importance for strengthening the production of local, novel foods, the design of marketing strategies, and the development of tailored food policies. The heterogeneity of the contextual and individual conditions implies the identification of homogenous consumer groups (e.g. according to economic conditions, age, education levels, food security dimensions, etc., Visschers et al. 2013). By segmenting the consumers' food preferences, habits, and nutritional needs, policy makers as well as producers can better evaluate the relevant challenges and provide customized measures to improve the consumers' diet quality and overall health.

Despite several seminal studies focus on assessing food consumer profiling and segmentation, limited research has been conducted in the African continent. To fill this gap, we seek to enhance the overall understanding of African urban consumers' preferences and behaviours by exploiting a rich dataset with observations collected in cities from both Northern and Sub-Saharan African countries (Kenya, Morocco, Tanzania, and Tunisia). Our main research questions are: (i) Can we identify groups of African urban consumers with similar food security, diets and behavioural profiles? (ii) Can we link such groups to the urban consumers' stated propensity to adopt nutritional dietary

¹ Prevalence of undernourishments is the percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life (The World Bank 2024).

² In this article, we follow the definition of food system used by FAO: "the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products" (FAO 2014).

³ i.e. "food value chain that has been shaped to alleviate constraints in the supply or demand of food, as they relate to dietary and nutrition problems" (European Commission, 2024).

innovations as well as to socio-demographic variables? The results of our analysis, classify African urban consumers into four groups with diverse dietary habits, behavioural patterns, and associated socio-economic and demographic characteristics. Based on this, we were able to shortlist and provide ad hoc nutritional recommendations for the four groups.

Literature on urban food consumer profiling and segmentation is vast. However, studies are not always comparable as the type of variables chosen for analysis varies considerably. A review performed by Verain et al. (2012), on segments of food consumers, identifies four groups of variables chosen for profiling and segmentation: (i) socio-demographic variables, (ii) personality characteristics, (iii) food-related lifestyles, and (iv) behaviours. Variables of groups (i) and (iv) are mostly used for profiling consumers rather than segmenting the sample. Gazdecki et al. (2021) identify seven categories of variables, without explicitly differentiating between variables used for profiling and those used for segmentation: socio-demographics variables, environmental, behavioural, psychographic, economic, affective and lifestyle-value factors. These studies indicate that our approach, which employs behavioural and diet quality variables for food consumer segmentation, is aligned with the existing literature.

Recent former studies have segmented food consumers through different research angles. Chen and House (2022) focused their analysis on health-related clusters of US consumers and profiled them using demographic variables. Aprile et al. (2016) segmented Italian food consumers according to their behaviour towards local food. Buitrago-Vera et al. (2016) segmented the Spanish food market based on consumers' food-related lifestyles and associated emerging clusters with the consumption of rabbit meat. Funk et al. (2021) segmented Swiss consumers on the base of environmentally friendly food consumption, and profiled clusters using personality and socio-demographic variables. Gazdecki et al. (2021) segmented consumers in Poland based on a sustainable approach to the consumption of food. Verain et al. (2016) segmented consumers in the Netherlands on the base of sustainability attributes, and then profiled groups on their perceptions of synergy between healthiness and sustainability of food products. Finally, Gonera et al. (2021) used the frequency in consumption of specific products, such as meat, seafood and fruit/vegetables to distinguish groups of Norwegian consumers.

Most of the studies on consumers segmentation deal with surveys at national level. Cross-sectional studies including more than one country are rare. Few exceptions include a study by Onwezen et al. (2012), which segmented consumers from the Netherlands, Greece, Poland, and Spain on the basis of the importance attached to benefits related to health, convenience, satiety (i.e. physiological need to fuel the body), sensory aspects, affect (i.e. good memories from childhood) and personal norms, and Verain et al. (2020), which segmented consumers' present versus future food choice motives, in the Netherlands, Germany, France, the United Kingdom, Poland, Spain, Greece, Croatia and Serbia. If the first study shows that meaningful cross-national consumer groups can be identified, the second showed significant differences in the importance of food choice motives across countries.

Our approach, which assesses consumers diet patterns and behaviour across four African countries, provide a relevant contribution to the literature focusing on

cross-country consumer segmentation. Furthermore, most of the abovementioned studies use survey-based data and thus report on stated preferences of consumers. It is well established in the literature that consumer stated preferences might be very different from their actual behaviour, the so-called Intention-Behaviour Gap or Say-Do Gap; (Sheeran 2002; Sultan et al. 2020). The novelty of this study lies in segmenting urban consumers on the base of behavioural precursors (in particular, trust, attitude towards risk, and cooperation potential) collected through incentivised experimental games, where monetary rewards are offered to players participating in a digital game to elicit their preferences and realistic choices.

Finally, only a sparse number of segmentation studies have been conducted in Africa. Two examples are a segmentation analysis in Tunisia to identify organic consumers types (Callieris et al. 2016), and an analysis of food consumers in Malawi according to mood, health, price and preparation convenience, familiarity, and sensory appeal (Gama et al. 2018). Our work provides novel field evidence on African urban consumer traits extremely helpful for the designing of tailored nutritional recommendations and the development of local NSVCs.

Methodology

Based on the abovementioned research objectives, two analytical steps were identified: (i) analysing the urban consumers' self-declared needs, values, motivations, and food choices in different African cities, (ii) examining their elicited propensity to include new foods in their diet. To gather this set of information, two combined data collection methods were employed: standardized structured surveys and incentivized economic in-lab experiments, respectively.

Sampling procedures

The data collection involved sampling urban consumers residing in nine cities across four African countries: Kenya, Morocco, Tanzania, and Tunisia (Table 1).⁴ In each city, from September 2021 to March 2022, 500 targeted urban consumers were recruited by local enumerators through randomly stratified sampling based on gender and age.⁵ When one gender (usually males) was poorly represented, it was oversampled to shed light on dynamics and conditions that would otherwise be overlooked. Only consumers with a residence in an urban area and responsible for food shopping within the household were sampled. To ensure that the sample was representative of the urban population, gender-balanced local enumerators sampled consumers outside food stores in different city neighbourhoods and in the proximity of various food distribution systems (e.g. supermarkets, grocery stores, wet and food markets, areas with many street vendors, etc.). In four cities, one in each country, surveys were combined with incentivized economic in-lab experiments (Table 1). Participants in the experiments conducted in the four cities were the same subjects who took part in the survey activities and were recruited outside food stores.

⁴ Participants that did not disclosed information on gender were excluded from the current study (N=11).

⁵ Strata were derived from urban population statistics on gender and age available in all countries. Local administrative authorities including county commissioner, chiefs, assistant chiefs and estate council leaders, supported to define the city boundaries when these were not immediately clear (e.g. Nyeri, Kenya).

Table 1 Study areas and sample characteristics

City	Country	2024 population ¹	Sample survey			Sample experiments ²		
			Males	Females	Total	Males	Females	Total
Kisumu	Kenya	216,479	184	308	492			
Kitui	Kenya	15,954	245	261	506	129	130	259
Nyeri	Kenya	51,084	218	292	510			
Beni Mellal	Morocco	166,399	282	118	400			
Meknès	Morocco	545,705	338	162	500	175	65	240
Sousse	Tunisia	164,123	181	317	498	101	132	233
Tunis	Tunisia	693,210	248	253	501			
Dar es Salaam	Tanzania	2,698,652	218	270	488			
Morogoro	Tanzania	250,902	241	260	501	241	260	501
Total			2155	2241	4396	646	587	1,233

¹ Data retrieved from worldpopulationreview.com

² The sample reported for the experiments include only subjects that have participated in all games considered in this study: risk preferences, time preferences, and trust game

Standardized surveys

The survey gathered information from 4396 urban consumers (responsible for food shopping within the household) on: food purchasing habits and decisions, consumer preferences towards new local and/or more nutritious food, individual dietary quality, household diet diversity (HDDS), socio-economic and demographic household information, consumer setbacks and worries, social capital, trust, and risk attitudes (survey instrument provided in the Supplementary material 1). A consent form (in the local language of each city) was used to collect consent from participants to take part in the experimental and survey activities.

To ensure standardized data collection, the survey was conducted using a custom app developed in WordPress, which replicates the survey questionnaire online. The app was used directly on tablets to collect data in all areas where internet conditions permitted. In cities with limited internet access, such as Kisumu (Kenya) and Tunis (Tunisia), data were collected by enumerators using pen and paper and later entered into the online app to maintain data consistency. Local teams translated the survey into local languages and input the translations directly into the app interface.

Through the Diet Quality Questionnaire, we collected standardised data of dietary adequacy and health protection against non-communicable diseases across countries (Global Diet Quality Project 2022). This questionnaire measures the consumption of 29 food groups (reported in Appendix 1), selected on the basis of their relationship to nutrition and health, sustainability and food-based dietary guidelines, and in line with United Nations indicators and recommendations. The methodology used to define the groups is based on a listing of standardized food groups, with the food items included in each group being the "sentinel food"—the most frequently consumed item within a food group in a given population. The food groups were defined by the Global Diet Quality Project, a collaboration between Gallup, Harvard Department of Global Health and Population, and the Global Alliance for Improved Nutrition (GAIN) (Global Diet Quality Project 2022). The Global Diet Quality Project provided preliminary versions of the

questionnaires for each country, and local teams gave feedback on which food items to include or exclude, as well as on suitable local translations.

Economic in-lab experiments

Incentivized in-lab experiments are controlled, lab-based studies where participants are given financial incentives to make decisions in a simulated economic environment. These experiments are widely used in economics and behavioural sciences to provide information on how people make economic decisions and behave under a series of controlled scenarios (showcasing, i.e. cooperation mechanisms, altruism, risk and trust preferences, etc.). These experiments were used to elicit urban consumers' actual choices and behaviours. The revealed preferences of the consumers were then deduced from observing the choices subjects made in controlled and standardized experimental settings. Our working hypothesis was that understanding how consumers behave in controlled experiments allows for more accurate predictions of real-world behaviour and decision-making.

The experiments consisted in five games presented in a random order to the participants: (i) a risk preferences (RP) game to measure consumers' risk attitude, (ii) a time preferences (TP) game to measure the propensity of respondents to expect delayed utility, (iii) a trust game (TG) to measure the degree of trust in peers and institutions, (iv) a Public Good Game to investigate the willingness of individuals to contribute to public goods, and finally (v) a Dictator Game to investigate the degree of altruism. Not all subjects participating to the experiments played all games. This research study only used information from the first three games: RP, TP, and TG.

The experiments were conducted in two alternating blocks to reduce the length of the experimental sessions: the RP and TP games were played in both blocks (hence by all targeted 500 urban consumers), while the TG, was played only in either block 1 or 2 (approximately half of the sample). Each experimental session comprised approximately 20 subjects and lasted around 3 h, encompassing the completion of the questionnaire. The sessions took place in laboratory settings, using oTree—an open-source platform for behavioural experiments—to conduct and collect respondent choices. Stakes were expressed in experimental tokens.⁶

RP were elicited through a multiple price list method (Holt and Laury 2002), in which each subject is presented with a list of 10 choices between pairs of gambles (labelled Option A and Option B). The participant then chooses which bet they prefer between the two. The payoffs of the Option A and Option B bets remain constant; the only thing that changes between decision lines is the probability associated with each payoff. The sequence of decisions is designed so that only those who are willing to take the risk will choose option B in the first choices. The number of times the participant chose option B was used as an indicator of risk appetite.

A fixed-sequence choice titration has been used in TP experiments (Andersen et al. 2008; Hardisty and Weber 2009; Harrison et al. 2004; Read et al. 2005). In this approach,

⁶ Tokens are incentives used to influence behaviour, often within the context of behavioural interventions or experimental settings. They are symbolic rewards that can be exchanged for monetary rewards or benefits at the end of the experimental session.

subjects are presented with a series of binary intertemporal choices between a fixed amount due at one point in time (hereafter referred to as smaller sooner) and a larger amount due at a later point in time (hereafter referred to as larger later). While the smaller sooner amount remains fixed, the larger later amount increases successively. In this case, the indicator of the propensity to expect deferred utility is derived by counting the larger later choices.

The TG is played in pairs and each player has 100 tokens as an initial allocation. There are two roles in the game: Sender and Receiver. Participants play both roles. When acting as senders, subjects can choose to send 0, 25, 50, 75 or 100 tokens to the receiver. The decision is kept private and the amount chosen to be sent is tripled before is passed on to the receiver. When acting as receivers, subject can choose how much to give back for each possible choice of the sender before knowing their actual choice. Two rounds of the TG were played. In the second round, the receiver is not played by an individual participant, but a local NGO or farmers' association.⁷ The proportion of tokens sent to other participants and institutions was used as a measure of trust towards peer consumers and food institutions.

At the end of the experimental session, the subjects were given a show up fee and a payoff based on the results of the five games. Participants' travel costs were also covered. Payoffs were converted into local currencies, using a rate that ensured the same average payoff at purchasing power parity across the four countries. In total, 2005 subjects took part in the experimental sessions, of which 1233 played all games considered in this study (RP, TP and TG) and thus used as final experimental sample. The experimental procedures are available in Zenodo (Marini Govigli et al. 2022).

Variable design

To identify dietary and behavioural profiles of urban consumers linked to socio-economic and demographic factors, two main set of indicators were used: (i) dietary information collected through the Diet Quality Questionnaire (see Sect. "Standardized surveys") and (ii) behavioural precursors collected through the in-lab experiments (see Sect. "Economic in-lab experiments").

The data collected through the Diet Quality Questionnaire were used to develop a series of indicators for assessing the nutritional adequacy of the diets among urban consumers. Diet quality indicators were based on Herforth (2023). Four behavioural variables were instead derived from the experimental session, measuring the consumer's (i) risk propensity, (ii) patience, (iii) trust towards peers, and (iv) towards the food value chain (Table 2). A problem that arises in choice list elicitation procedures (such as RP and TP) is the observation of multiple switching behaviour, which violates the monotonicity and transitivity of revealed preferences (Finger et al. 2023; Harrison et al. 2004). On average, 33% of subjects exhibited inconsistencies in either the RP or TP games across the four countries (see Appendix 2). These responses were subsequently excluded from the analysis, reducing the overall sample from the behavioural experiments to 795 units.

⁷ The choices of the institutions playing as receivers were recorded prior to the starting of the experimental session.

Finally, two variables derived from the survey results were used to assess consumer preferences: (i) for new local foods and (ii) for more nutritious foods (Table 2). These variables were employed to test the association between behavioural patterns, dietary quality, and the consumer's propensity to adopt dietary innovations.

Data analysis

Data analysis to identify homogeneous groups of consumers was conducted using cluster analysis. Cluster analysis is a set of statistical techniques designed to classify similar objects into groups that maximize homogeneity within the groups while maximizing differences between them. The analytical process is summarised in Fig. 1.

As a first step, two cross-country cluster analyses were implemented to identify homogeneous types of urban consumers in terms of their dietary quality and behavioural attitudes:

1. A cluster analysis focusing on the urban consumers' dietary quality. In this cluster analysis, we profiled urban consumers according to the indicators characterizing the consumer's diet reported in Table 2.
2. A cluster analysis focusing on the urban consumers' revealed preferences. In this analysis, we profiled urban consumers according to a series of information on behavioural precursors (e.g. trust, risk, and temporal revealed preferences) collected through the organization of incentivized in-lab behavioural experiments (Table 2).

The two analyses were run separately since the behavioural experiments were conducted only in four cities out of nine and thus have a different sample size. We believe this mixed approach allows us to retain the richness of the sample in terms of city diversity while also assessing behavioural precursors affecting consumer choices regarding their diets.

The steps we followed to perform both cluster analyses were: (i) defining the variables used for clustering the units, (ii) selecting a measure of dissimilarity between the units, (iii) selecting an appropriate clustering algorithm, (iv) determining the optimal number of groups for partitioning the sample, (v) segmenting the groups with respect to the features analysed (vi) profiling the groups through socio-economic descriptors.

The definition of the variables (i) reflects our research hypotheses and were described in the previous paragraph. The selection of the measure of dissimilarity (ii) is closely tied to the nature of the variables being investigated. In the analysis of behavioural patterns, being primarily quantitative data, a Euclidean distance was used after standardising the variables. In the analysis related to diet quality, The Gower metric (Gower 1971) was used to calculate the distance matrix between the units, given that the data are of mixed nature (dichotomous qualitative variables and quantitative variables).

Regarding the classification algorithm (iii), both hierarchical and partitioning methods were considered. For the former, agglomerative models using Ward's method and

Table 2 Diet quality variables based on (Herforth 2023), Behavioural variables derived from the in-lab incentivized experiments, and consumer preferences for new local foods and for more nutritious foods derived from the survey

	Variable code	Dietary indicator	Type	Levels
Diet quality variables	Vegetable_fruit	Vegetable or fruit consumption	Binary	0:1
	AnimalSource	Animal-source food consumption	Binary	0:1
	SweetBeverage	Sweet beverage consumption	Binary	0:1
	SugarSweetDrink	Sugar-sweetened soft drink consumption	Binary	0:1
	SweetFood	Sweet foods consumption	Binary	0:1
	SaltyFriedSnack	Salty or fried snack consumption	Binary	0:1
	WholeGrain	Whole grain consumption	Binary	0:1
	Pulse	Pulse consumption	Binary	0:1
	NutsSeeds	Nuts and seeds consumption	Binary	0:1
	ProcessedMeat	Processed meat consumption	Binary	0:1
	All.5	All-5 score	Binary	0:1
	NCD_P	Non-Communicable diseases NCD-Protection score	Numeric	0:9
	NCD_R	NCD-Risk score	Numeric	0:9
	GDR	Global Dietary Recommendations score (GDR)	Numeric	0:18
	FGDS	Food Groups Dietary Diversity Score (FGDS)	Numeric	0:10
Behavioural variables	Risk	Urban consumer's risk propensity	Numeric	1:10
	Time	Urban consumer's patience score	Numeric	0:10
	Player.trust	Consumer's trust towards peers (average endowment sent to peers' receivers)	Numerical categories	0; 25; 50; 75; 100
	Player.trust_inst	Consumer's trust towards food value chain (average endowment sent to food institutions)	Numerical categories	0; 25; 50; 75; 100
Innovation propensity variables	Local_food_interest	Consumer's propensity in introducing a local food product in the diet	Numeric	1:5
	Nutri_food_interest	Consumer's propensity in introducing a higher nutritional food product in the diet	Numeric	1:5

the complete linkage method were evaluated, and for the latter, k-means and k-medoids (partition around medoids) were used. The main difference between the two methods is in the way the group centres are defined. K-means takes the mean of the data points

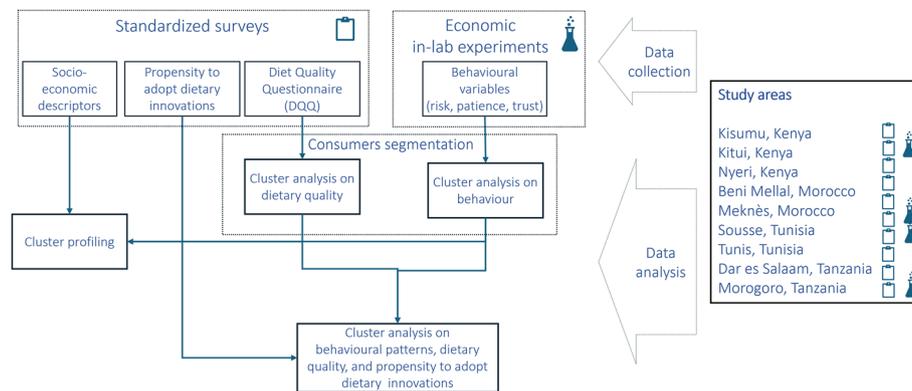


Fig. 1 The analytical process employed in this research study. Own elaboration

to create new points called centroids. K-medoids instead uses data points as centres, called medoids, which are determined so that the total dissimilarity of all points from the nearest medoids is minimal. It should be noted that k-means requires a quantitative data matrix as input, so it was not possible to use it in the case of diet quality analysis. Internal validation indices were adopted in order to assess which algorithm was the most appropriate and at the same time the optimal number of groups. These indices are used to measure the quality of a clustering result against others produced by other clustering algorithms or by the same algorithms but with different parameter values. The indices used were: Calinski and Harabasz index, Davies–Bouldin validity index, Silhouette index, and C-index. The first two are based on the sum of squares within the clusters and therefore cannot be used for mixed data.

The results provided by these indices may sometimes be inconsistent, as they sometimes produce different optimal solutions, but they still provide a first indication of what the best clustering strategy might be. The indications provided by these indices must also be weighed against the need for knowledge and synthesis, e.g. an optimal solution with a very high number of groups may not help in synthesising the phenomenon, so a compromise must be found between the need for synthesis and the values assumed by the index. Once the cluster analysis had been carried out, the groups were profiled in order to describe them in terms of input variables. This involved the use of descriptive statistical methods and tests to understand which quantitative variables and/or qualitative variables best characterised the groups.

In the first cluster analysis, focused on the dietary quality of urban consumers, the partition around medoids algorithm gives better results for all indices. Regarding the choice of the optimal number of groups (iv), no significant differences were found when comparing the Silhouette scores between the different groupings (Appendix 3). We then chose a partition of the sample that would not lead to an overfitting of the groups. Based on this analysis, the partition around medoids method and a 4-group configuration were chosen. In the second cluster analysis focusing on the revealed preferences of urban consumers, we observe that the Calinski–Harabasz and Silhouette indices reach their maximum value with four-group partitioning for the k-means algorithm. The Hubert & Levin C-index, for which the optimum corresponds to the minimum value, tends to decrease as the number of groups increases, but a strong decrease is observed for four-group

Table 3 Clusters segmentation according to the diet quality variables considered. Variable descriptions are provided in Table 2

Variable	Group D1: Consumers with unbalanced diets	Group D2: Consumers with unhealthy diets	Group D3: Consumers with balanced and healthy diets	Group D4: Consumers with balanced yet unhealthy diets	Total
Vegetable_fruit ¹	94.50	97.30	100.00	100.00	98.00
AnimalSource ¹	89.20	97.90	97.30	99.50	95.70
SweetBeverage ¹	76.40	93.30	84.10	85.90	83.80
SugarSweetDrink ¹	6.00	69.70	18.50	33.00	26.80
SweetFood ¹	25.30	82.70	26.30	65.40	45.70
SaltyFriedSnack ¹	18.30	80.50	30.40	76.00	47.60
WholeGrain ¹	23.30	25.10	25.20	73.50	38.70
Pulse ¹	18.60	18.50	90.40	76.00	55.20
NutsSeeds ¹	7.70	18.60	26.00	78.50	34.90
ProcessedMeat ¹	8.10	24.80	9.30	22.70	15.10
All.5 ¹	2.60	18.80	93.20	96.90	57.60
NCD_P ²	3.04	3.81	5.05	6.58	4.74
NCD_R ²	1.32	4.15	1.76	3.91	2.61
GDR ²	10.71	8.66	12.29	11.67	11.13
FGDS ²	5.11	6.26	7.26	8.45	6.85

¹ Dummy indicators for which is shown the % values of 1 (=yes)

² Average values

partitioning, after which the decrease slows down (Appendix 4). Based on this analysis, the k-means method and a four-group configuration were selected.

In a further step, we examined the relationship between the groups identified by the clustering procedures (i.e. consumers' segmentation) and the main socio-economic variables (i.e. consumers' profiling). In the case of numerical variables, ANOVA or nonparametric tests (Kruskal–Wallis rank sum test) were used, taking into account the results of the normality check. For qualitative variables, the Chi-square test was used. In the case of dependency, we identified the aspects in which the groups differed with respect to these variables, using post hoc tests in the case of numerical variables or association diagrams based on the residuals of the Chi-square test for qualitative variables.

Finally, we carried out a last cluster analysis using the groups obtained from the previous analyses to test the relationship between behavioural patterns, dietary quality, and the consumer's propensity to adopt dietary innovations. The analysis employed a partition around medoids-type cluster with four groups (Appendix 5).

Results

Clusters on dietary quality

The four groups (D1, D2, D3, and D4) based on the dietary quality patterns of urban consumers identified through cluster analysis are given in Table 3 and Fig. 2:

Group D1: "Consumers with unbalanced diets" This group comprises 1118 urban consumers, accounting for 28.3% of the total sample. Consumers in this group are characterized by a deficiency in dietary diversity, with a notable aspect being that only 2.6% of them consume the recommended five food groups (All.5; Table 3) Additionally, their diet is centred around the consumption of fruits and vegetables (94.5% of consumers)

and animal-source foods (89.2%). However, these percentages are lower compared to the other groups, as are the consumption shares of all other product categories. The scarcity is evident in the Food Group Diversity Score (FGDS), which records the lowest value at 5.11.

Group D2: “Consumers with unhealthy diets” This group includes 585 urban consumers (14.8% of the total). The consumers belonging to this group are characterised by a diet mostly made of fruit and vegetables (97.3%), animal-source food (97.9%) and a series of unhealthy products as sweet beverages (93.3%), sugar-sweetened drinks (69.7%), sweet foods (82.7%), salty or fried snacks (80.5%), and processed meat products (24.8%). Their food consumption habits are predominantly unhealthy: ultra-processed food consumption (NCD-R) is the highest on average across the four groups (4.1), and only 18.8% of them consumes the recommended five food groups (all-5). The GDR score is also the lowest on average across the four groups (8.7).

Group D3: “Consumers with balanced and healthy diets” This group includes 1100 urban consumers (27.9%). These consumers show a balanced and healthy diet, with 93.2% of them consuming the five recommended food groups (all-5) and showing an above-average FGDS (7.26) and GDR (12.29). The rate of ultra-processed food consumption is the lowest recorded (1.76). They are characterised by having a diet made of

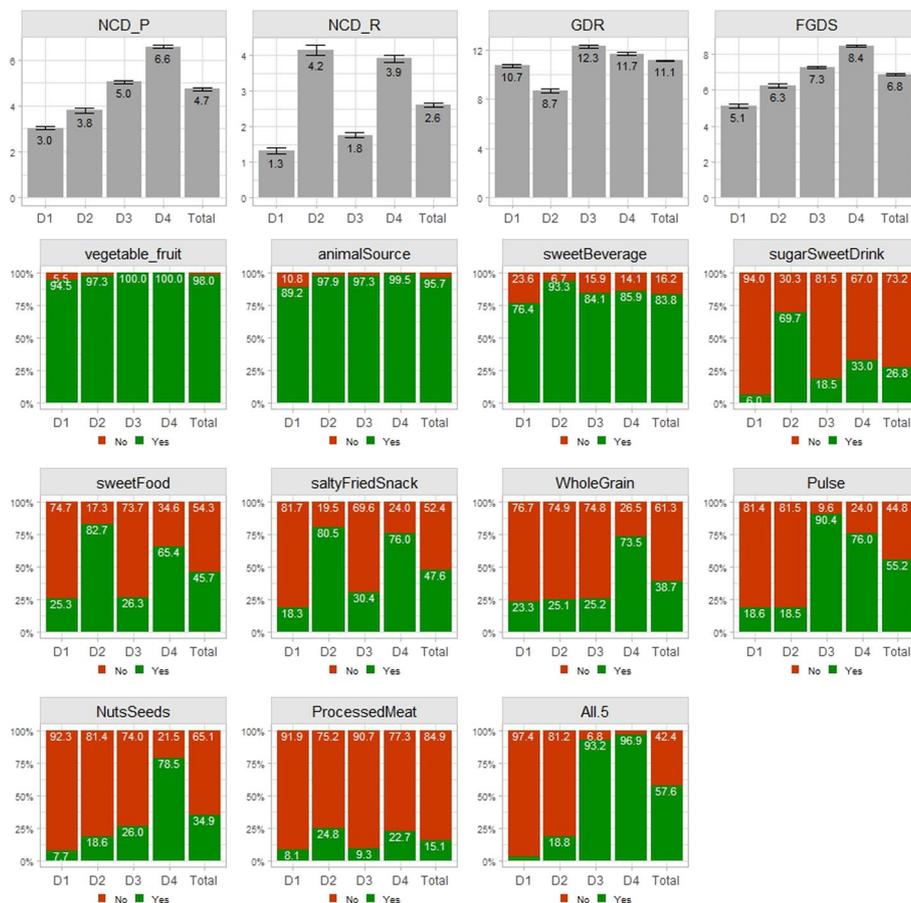


Fig. 2 Clusters segmentation according to the diet quality variables. Numerical variables are grey shaded; the cluster is reported with a 95% confidence interval. Variable descriptions are provided in Table 2

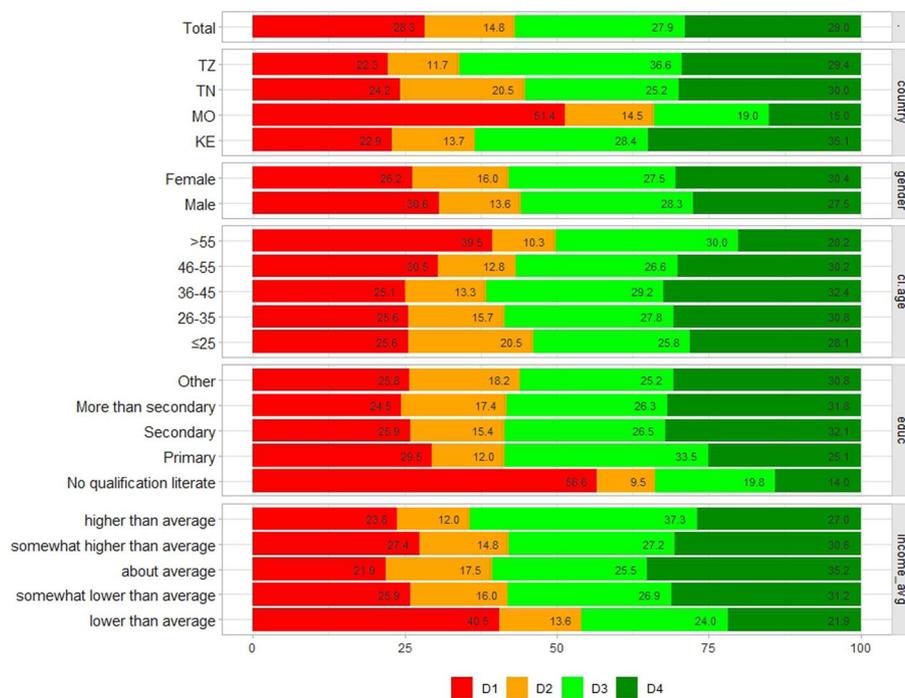


Fig. 3 Diet quality cluster profiling by selected socio-economic variables

healthy and recommended products as fruit and vegetables (100%), animal-source food (97.3%), pulses (90.4%), except for sweet beverage products (84.1%).

Group D4: “Consumers with balanced yet unhealthy diets” This group includes 1144 urban consumers (29%). This group is characterised by urban consumers having a higher-than-average balanced and healthy diet, yet characterised by some unhealthy habits (e.g. consumption of ultra-processed food items). The NDC-R score is high (3.9), despite almost all consume the five recommended food groups (96.9%). Their diet comprises several healthy food products as fruit and vegetables (100%), animal-source food (99.5%), pulses (76%), whole grain products (73.5%), and nuts and seeds (78.5%). However, it also includes several unhealthy products as sweet beverages (85.9%), sweet foods (65.4%), salty or fried snacks (76%), and processed meat products (22.7%).

The analysis of the relationship (i.e. profiling) between the groups and the socio-economic variables shows a significant dependence between these variables (Table 7; Appendix 3). Group D1 is mainly characterised by consumers from Morocco, who are male, of advanced age, with no education and low income; Group D2 is associated with Tunisia and shows a prevalence of young women with high education and average income; Group D3 is associated with consumers from Tanzania, with primary education and high income; Group D4 is associated with Kenya, with a slight prevalence of women of middle age, with high education and average income (Fig. 3).

Clusters on behaviour

Four groups of urban consumers (B1, B2, B3, and B4) with different behavioural patterns were identified from the second cluster analysis (Fig. 4):

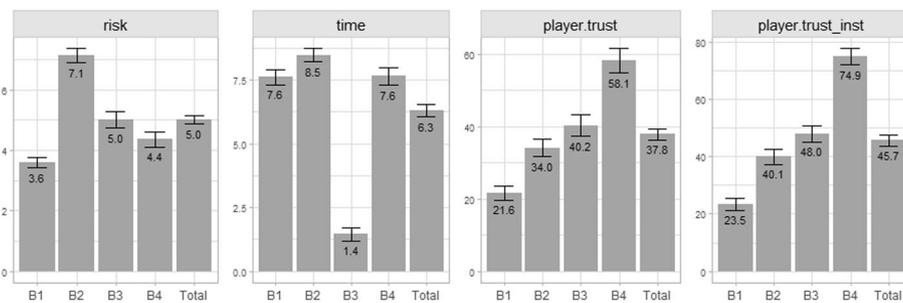


Fig. 4 Clusters segmentation according to the behavioural variables. Mean bars are reported with a 95% confidence interval. Variable descriptions are provided in Table 2

Group B1: 'Patient, risk-averse and suspicious consumers' This group comprises 214 urban consumers (26.9% of the total). Consumers in this group are characterised by high levels of patience (7.6), high levels of risk aversion (3.6) and the lowest levels of trust. This distrust concerns both peers (to whom they gave only 21.6 tokens on average) and institutions (23.5).

Group B2: 'Patient and risk-taker consumers' This group includes 199 urban consumers (25% of the total). The members of this group are characterised by a high level of patience (8.5) and a high level of risk-taking (7.1), while there is a medium level of trust.

Group B3: 'Impatient consumers' This group includes 197 urban consumers (24.8% of the total). They are characterised by extreme impatience (1.6), while their attitude to risk is neutral (5) and their level of trust is slightly above average.

Group B4: 'Confident and patient consumers' This group comprises 185 urban consumers (23.3% of the total) and is mainly characterised by a high level of trust in both other people (58.1) and institutions (74.9). They are also very patient consumers (7.6) and moderately risk-averse (4.4).

The analysis of the relationship between the clusters and the socio-economic variables shows a significant association by country, with Kenya being mainly characterised by Group B1, Tanzania by Group B2, Morocco by Group B3 and Group B4 with Tunisia (Appendix 3, Table). Level of education and income also show significant but less pronounced relationships with the groups. Groups B1 and B4 tend to be more present among those with a secondary education and those with more than a secondary education, respectively, while those with no education are associated with Group B3. Finally, higher incomes can be associated with the first two groups, medium–high incomes with Group B4 and lower incomes with Group B3 (Fig. 5).

Behavioural patterns, dietary quality, and consumer's propensity to adopt new foods

In the last step, we investigated the relationship between the two previous clusters, focusing on diet quality and behaviours, and urban consumers' inclination to innovate in their diets. In the following paragraphs we provide a description of the four groups (I1, I2, I3, and I4) using diet quality, behavioural and socio-economic information of the sample (Figs. 6 and 7).

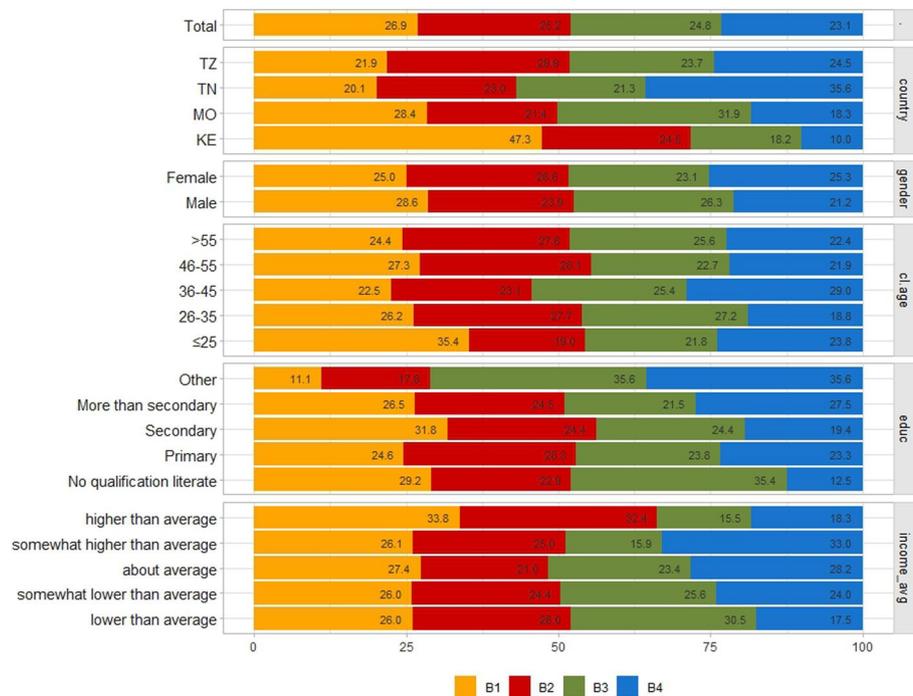


Fig. 5 Behavioural cluster profiling by selected socio-economic variables

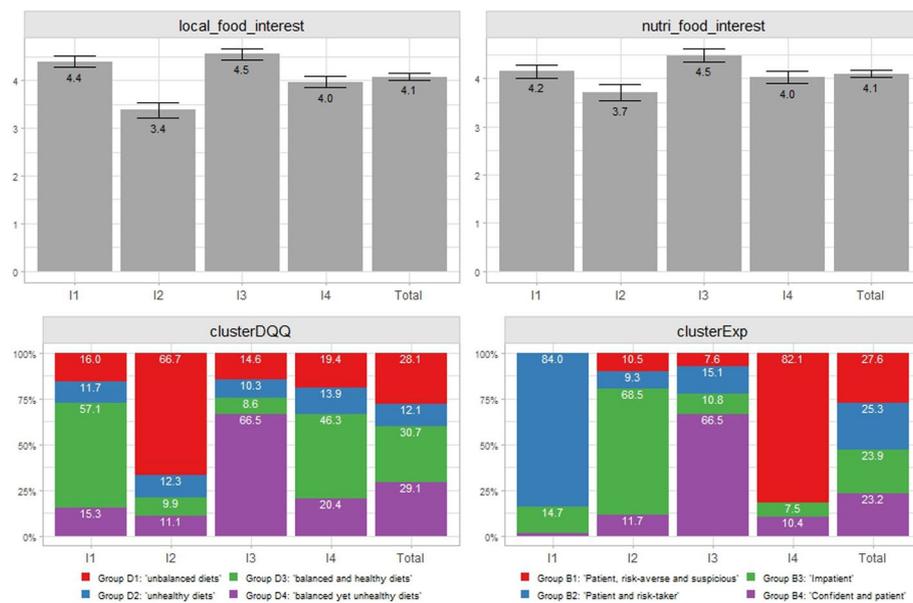


Fig. 6 Clusters segmentation according to the two cluster analyses and innovation propensity variables. Mean bars are reported with a 95% confidence interval. Variable descriptions are provided in Table 2

Group I1. “Patient, healthy and innovation propense consumers” This group is characterized by the presence of consumers ($N=163$; 22.9% of the total) with a balanced and healthy diet, and high income (Group D3), who are patient and willing to take

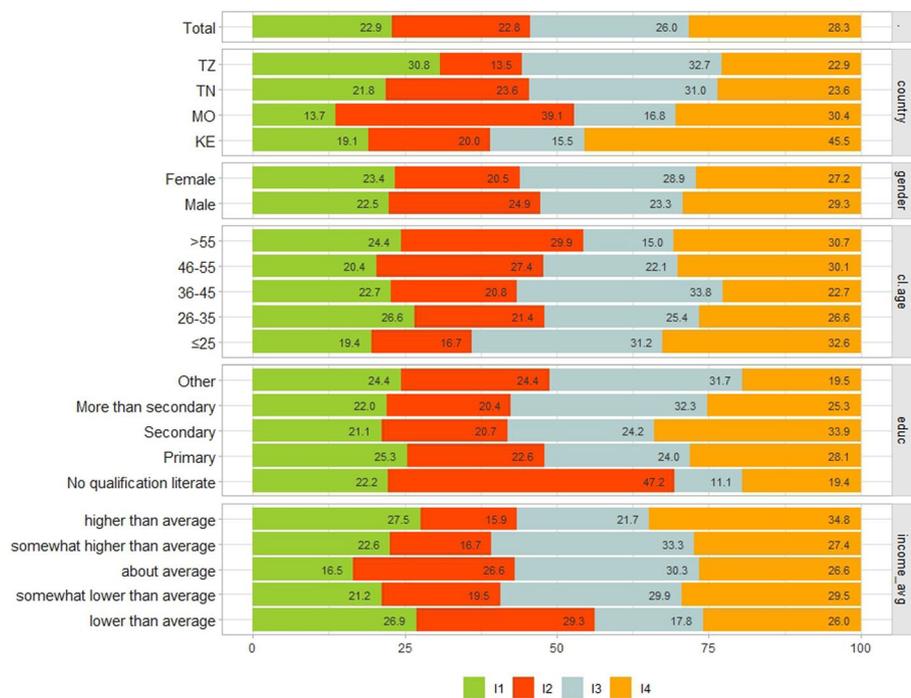


Fig. 7 Joint cluster profiling by selected socio-economic variables

risks (Group B2) and who tend to innovate their diet, particularly with new local products.

Group I2. “Impatient, unbalanced, innovation-averse consumers” This group is made of 162 consumers (22.8%) with an unbalanced diet (Group D1) and impatience (Group B3), who are the least interested in the introduction of new foods. Group I2 is also characterised by the highest average age, lowest education level and income level, and the greatest difficulty in meeting food need.

Group I3. “Unhealthy, trusty and innovation propense consumers” This group consists mainly of consumers (N=185; 26.0%) with a balanced but unhealthy diet (Group D4), who trust others (Group B4) and are the most interested in introducing new foods. Group I3 is made up of younger consumers with a generally higher income and few difficulties in meeting food needs.

Group I4. “Healthy, impatient and risk-averse consumers” This group is characterized by the presence of consumers with a balanced and healthy diet and, in particular, a high proportion of patient but risk-averse and suspicious consumers (Group B1), with an interest in new foods that does not deviate from the overall average. This latter group comprises 201 urban consumers (28.3% of the total).

Discussion and conclusion

Linking behavioural drivers to consumer food choices

In this paper, our aim was to establish a new segmentation procedure of African urban consumers by considering both dietary patterns and behavioural drivers and to profile them by associating relevant socio-economic characteristics. This was done with the intention of offering policymakers and operators homogeneous target consumer groups,

which can allow for the development of tailored nutritional recommendations, and enhanced NSVCs. Our findings identify four groups of urban consumers, with different dietary and behavioural traits, linked with a diverse propensity to innovate their diets.

Our study demonstrates the significance of integrating consumer behavioural information with their dietary patterns and orientation to effectively address food insecurity. The three behavioural characteristics we evaluated—patience, risk aversion, and trust—all seem to play a role in shaping dietary choices. This finding aligns with the extant literature that explores the relationship between behavioural traits and consumer diets. Intertemporal preferences (the propensity of respondents to expect delayed utility) have been identified as directly influencing consumer responses to health-related claims. For instance, impatient consumers are more inclined towards short-term benefits and may resist long-term dietary changes (De Marchi et al. 2016). This observation is consistent with our cluster analysis, where impatient consumers, belonging to Group I2, tend to avoid innovations in food choices, while patient consumers, grouped under I1, exhibit healthier and more balanced dietary habits and higher propensity to revise their diet. A notable exception is from Group I4, where consumers are characterized by impatient behaviours alongside exhibiting healthy diets and low interest in adopting food innovations. This contradictory finding may stem from the use of experimental economics methods to gather behavioural data, which in some contexts have been observed to lack full stability and consistency. Further investigation is needed to clarify the directionality of the effect of intertemporal preferences (Chuang and Schechter 2015).

Prior literature on risk preferences and consumers' diet revealed that risk-seeking consumers tend to exhibit less healthy dietary habits (Nebout et al. 2023), despite temporal preferences seeming to play a more prominent role in long-term dietary changes. Our findings contradict previous research, as healthy diets among African consumers are associated with either risk-seeking individual diets (I1) or risk-averse ones (I4). This suggests a nuanced understanding of the relevance of risk parameters in dietary assessments, as highlighted by the work of Nebout et al. (2023). Lastly, we examined the role of trust and its association with consumer diet healthiness and balance diets. Existing literature has established a direct correlation between consumers with a high level of trust in the food value chain and their inclination to purchase functional, healthy foods (Baker et al. 2022). On the opposite, our cluster analysis findings reveals that consumers characterized by high levels of trust (I3) tend to have unhealthy diets while exhibiting the highest interest in adopting new foods.

By addressing these aspects with closer attention, food operators can find insights to orient their strategies and policymakers can derive nutritional recommendations that may be more effective in achieving their long-term objectives regarding local food security and dietary improvements. These recommendations are provided in the following section.

Tailored nutritional recommendations

Based on our findings, in Table 4 we propose a set of targeted nutritional recommendations to address the needs of the four aforementioned groups. Through this assessment, we can prioritize groups that require immediate action to combat food insecurity in the studied cities: namely, Groups I2 and I3. Both groups exhibit suboptimal dietary

Table 4 Nutritional recommendations targeted to the four groups

Group	General recommendations	Specific recommendations
Group 11. "Patient, healthy and innovation propense consumers"	Maintaining Current Diet —Nutritional recommendations for sustaining a healthy and balanced eating pattern	<p>Limit intake of foods that are high in fat, sugar and salt Consume at least two servings of vegetables and one serving of fruits per day Train community health workers and nutritionists in educating individuals about the importance of physical activity (e.g. about 30 min per day for at least five days per week to prevent weight gain) and nutritious food consumption Monitor that the daily food consumption covers at least five of the recommended food groups</p>
Group 12. "Impatient, unbalanced, innovation-averse consumers"	Rebalance the Diet —Limit/avoid consumption of foods and substances that are hazardous to health	<p>Make effective use of mass-media to advocate for increased consumption of food groups which are protective from non-communicable diseases (unprocessed or minimally processed foods) and reduce the consumption of those with potential to pose non-communicable disease risks (ultra-processed foods) Promote consumption of diversified foods from the recommended food groups Support consumers to adjust to three meals a day, with breakfasts including high-nutrient-dense foods Engage nutritionists with community-based organisations to set up open conversation channels with consumers so to convince them to adopt a more active and monitored physical lifestyle Household head should be encouraged to prioritize diversified diets at household level</p>
Group 13. "Unhealthy, trusty and innovation propense consumers"	Innovate the Diet —Enhance the diet with innovative, nutritionally dense options. Provide consumers with ad hoc information emphasizing the importance of healthy eating and nutritious choices	<p>Develop engaging nutrition labels on food so as to support consumers in making informed choice when purchasing processed foods (e.g. warning signs) Promote healthy food preparation methods to avoid intake of high amount of unhealthy fats and oils Promote healthy food products through ad hoc marketing strategies Develop measures that can support consumers in completely avoid consumption of soft drinks and saturated fats Develop initiatives which can support consumers with ad hoc diet counselling that integrates physical activity with healthy diet practices Create healthy diet community groups to support one another in adopting and sustaining healthy dietary practices</p>

Table 4 (continued)

Group	General recommendations	Specific recommendations
Group 14. "Healthy, impatient and risk-averse consumer"	Maintaining Current Diet —Nutritional recommendations for sustaining a healthy and balanced eating pattern	Limit intake of foods that are high in fat, sugar and salt Consume at least two servings of vegetables and one serving of fruits per day Train community health workers and nutritionists in educating individuals about the importance of physical activity (e.g. about 30 min per day for at least five days per week to prevent weight gain) and nutritious food consumption Monitor that the daily food consumption covers at least five of the recommended food groups

patterns, with Group I2 displaying high imbalance and Group I3 showcasing highly unhealthy habits. However, what sets them apart is their willingness to adopt innovations, such as nutrient-dense foods, to improve their diets. Therefore, effective recommendations and habit shifts should focus on Group I2 by implementing actions aimed at rebalancing their diets, while for Group I3, efforts should concentrate on boosting nutritional performance through the development and adoption of new ad hoc products.

We focus now on the nutritional recommendations for Groups I2 and I3, which require immediate interventions. Consumers from I2 are often from the poorest urban populations. Utilizing multimedia for communicating nutrition messages becomes crucial for this group, emphasizing the consumption of diverse foods, diverse food practices (three meals a day) while limiting the intake of ultra-processed foods. Given their tendency to be innovation-averse, influential community leaders or health workers are essential for supporting the adoption of nutrition-based innovations. Furthermore, it is necessary to explore available and affordable nutritious foods and educate individuals during dedicated local events such as village nutrition and health days. In many African countries, nutrition messages primarily target women of reproductive age and children under the age of five years due to their vulnerability to nutrient deficiencies (Ainuson-Quampah et al. 2022). However, it is recommended to target all community members through various media campaigns because youths, and adolescents are future parents, and their purchasing behaviour is significantly influenced by marketing and promotional strategies.

Other strategies to enhance the nutritional quality of these consumers' diets include: (i) establishing kitchen gardens, either individually or in households or groups, to increase the availability and accessibility of nutritious foods at affordable costs, (ii) facilitating open and continuous conversations between nutrition experts and consumers to encourage the adoption of a more active and monitored physical lifestyle.

I3 represents a cluster of consumers with higher incomes and good ability to meet their food needs. However, their primary challenge lies in acquiring accurate and actionable information about healthy and nutritious diets. Despite their socio-economic status enables them to afford diverse diets, many of these consumers may still consume high-energy foods, leading to a higher risk of overweight and obesity due to limited physical activity. To address this, nutritionists, with the support of community-based outreach programmes, should engage in continuous conversations with these consumers. This communication should emphasize the importance of adopting a more active and monitored physical lifestyle, as well as growing (whenever possible) and consuming nutrient-dense crops and products (e.g. quinoa and tree tomato fruits). This information should be presented in a quick and easily digestible format using various media channels (e.g. social media, radio) or existing social gatherings (e.g. concerts, mass services, etc.). Other strategies include: (i) encouraging consumers to increase the consumption of non-communicable disease—protective foods while completely avoiding the consumption of soft drinks and saturated fats, (ii) developing tailored and engaging nutrition-based food labels to help consumers make informed choices about their food purchases, (iii) promote at public level the production, storage, and distribution of innovative healthy foods.

Conclusions

The results highlighted the diversity of behavioural and dietary profiles across urban consumers in the sampled African cities. The identified groups reacted differently also with regard to their stated propensity to enrich the household diet with new nutrient-dense or new local foods. This allowed us to derive different sets of nutritional recommendations tailored to the needs and context-specific variables of each group. The results of our study suggest that research, business, policy, and communication strategies aimed at fighting malnutrition should be shaped by the complexity and heterogeneity of the consumers' food conditions and the deriving objectives and actions (e.g. development of NSVCs) be tailored to meet the consumer group-specific preferences and needs.

Appendices

Appendix 1: Food groups included in the Diet Quality Questionnaire

Standardized food groups	Food items—Kenya	Food items—Morocco	Food items—Tanzania	Food items—Tunisia
	<i>Yesterday, did you eat any of the following foods?</i>			
01 Staple foods made from grains	Maize ugali, maize porridge, rice, bread, chapati, pasta, or noodles?	Rice, couscous made with semolina or ferina, bread made with ferina, pasta, mhamssa or berkoukesh?	Refined maize ugali, rice, pasta, bread, chapati, or kitumbua?	Couscous, bread, macaroni, rice?
02 Whole grains	Ugali made from millet or sorghum, porridge made from millet or sorghum, green maize, githeri, oats, or popcorn?	Millet, maize porridge, maize, barley or whole meal wheat processed at home?	Maize grains, roasted corn, boiled corn, wholegrain maize ugali, millet porridge, sorghum porridge, or sorghum ugali?	Barley, bulgur, sorghum, sohlob, oats, corn, popcorn?
03 White roots/tubers	Irish potato, white sweet potato, green banana, arrowroot, yam, or cassava?	Potatoes, turnip or Jerusalem artichoke?	Cassava, cassava ugali, makopa, yam, green banana, Irish potato, or white sweet potato?	Potatoes?
04 Legumes	Beans, githeri, green gram, black gram, green lentils, pigeon peas, or chickpeas?	White beans, lentils, chickpeas, fava beans or bisara?	Beans, green peas, cowpeas, green gram, pigeon peas, lentils, bambara nuts, or makande?	Beans, fava beans, lentils, chickpeas, peas?
05 Vitamin A-rich orange veg	Carrots, pumpkin, butternut, sweet potato that is orange inside, or red capsicum?	Carrots, pumpkin?	Carrots, orange pumpkin, or viazi lishe?	Carrots, pumpkin?
06.1 Dark green leafy vegetables	Sukuma wiki, spinach, nightshade leaves, amaranth leaves, African spider plant, or cowpea leaves?	Khbiza/bekoula, turnip greens, purslane, watercress or alfalfa?	Kale, spinach, Chinese amaranth leaves, cowpea leaves, or cassava leaves?	Swiss chard, jute mallow, spinach, parsley, turnip greens?
06.2 Dark green leafy vegetables	Jute mallow, pumpkin leaves, malabar spinach, mitoo, broccoli or Ethiopian kale?	Aubergines, courgettes, cabbage, tomatoes, green peppers or green beans?	Nightshade leaves, spider flower leaves, jute mallow, sweet potato leaves, or pumpkin leaves?	-

Standardized food groups	Food items—Kenya	Food items—Morocco	Food items—Tanzania	Food items—Tunisia
07.1 Other vegetables	Tomatoes, cabbage, green capsicum, mushrooms, or cauliflower?	Artichokes, cauliflower, kohlrabi, cucumber, beetroot or fennel?	Cabbage, tomatoes, African eggplant, eggplant, sweet pepper, cucumber, or okra	Tomatoes, cucumber, lettuce, cabbage, zucchini, eggplant, cauliflower?
07.2 Other vegetables	Cucumber, French beans, lettuce, eggplant, or okra?	-	-	okra, artichoke, radish, cardoon, fennel root, sweet green pepper, kohlrabi?
08 Vitamin A-rich fruits	Ripe pawpaw, ripe mango, or passion fruit?	Apricots, dried apricots or cantaloupe?	Mango, papaya, or passion fruit?	Apricots, dried apricots, cantaloupe?
09 Citrus	Orange, tangerine, or grapefruit?	Orange, mandarin or grapefruit?	Orange or tangerine?	Orange, mandarins, lim hlou?
10.1 Other fruits	Banana, pineapple, avocado, or watermelon?	Dried or fresh figs, plums, grapes, dates, pomegranate, watermelon or green melon?	Banana, pineapple, avocado, grapes, pear, or apple?	Dried or fresh grapes, dates, pomegranate, watermelon, green melon, banana?
10.2 Other fruits	Apple, pear, grapes, or guava?	Apple, pear, quince, prickly pear, peach, cherry or strawberry?	Watermelon, baobab, guava, or jackfruit?	Apple, pear, peaches, plums, strawberries, cherries?
11 Grain sweets	Cakes, cupcakes, or sweet biscuits?	Cakes, cookies/sweet biscuits, briouate hlouwa, churros or shbekia?	Cakes, cookies, visheti, or sweet biscuits?	Cakes, biscuits, gaufrette, makroud, baklawa, or other traditional Tunisian sweets?
12 Other sweets	Candy, chocolates, ice cream, or ice lollies?	Sweets, chocolates, ice creams and nougats?	Candy, chocolates, or ice cream?	Candies, chocolates, ice cream or popsicles, custard, mhalbiya?
13 Eggs	Eggs?	Eggs?	Eggs?	Eggs?
14 Cheese	Cheese?	Cheese, la vache qui rit, or cheese lehmer?	Cheese?	Cheese?
15 Yogurt	Yogurt or mala?	Rayeb, yogurt, or lebn?	Mtindi or yogurt?	Yogurt, lben, rayeb?
16 Processed meat	Sausages, Smokies, hot dogs, salami, or ham?	Kacher?	Soseji, ham, or bologna?	Ham, salami, kadid?
17 Unprocessed red meat (ruminant)	Goat, beef, minced beef, offal, mutton, or wild game?	Beef, goat, sheep or cow or sheep organs?	Beef, mutton, goat, offal, or grinded meat?	Beef, lamb, goat?
18 Unprocessed red meat (non-ruminant)	Pork, rabbit, or camel?	Rabbit or camel?	Pork, rabbit, or bush meat	Camel?
19 Poultry	Chicken, duck, turkey, quail, guinea fowl, or wild birds?	Chicken, turkey, pigeon, wild birds or chicken liver?	Chicken, duck, or guinea fowl?	Chicken, chicken liver, turkey?
20 Fish & seafood	Fish, dagaa, canned tuna, or seafood?	Fish, seafood or canned fish?	Fish, dagaa, dried small tilapia, shrimp, prawn, shellfish, or octopus?	Fish, ouzef, tuna, sardines, seafood such as shrimp?
21 Nuts & seeds	Groundnuts, cashews, pumpkin seeds, sesame seeds, or peanut butter?	Nuts, peanuts, almonds, amlu, or selou/sfouf	Pumpkin seeds, kashata za ufuta, cashews, groundnuts, or groundnut paste?	Almonds, peanuts, walnuts, hazelnuts, pistachios, kloub?
22 Ultra-processed packaged salty snacks	Crisps, Ringoz, Chooze, or Chevda?	Chips?	Packaged chips such as Lays, Pringles, or Doritos?	Chips?

Standardized food groups	Food items—Kenya	Food items—Morocco	Food items—Tanzania	Food items—Tunisia
23 Instant noodles	Indomie?	Indomie?	Instant noodles?	Indomie?
24 Deep fried foods	Chips, ngumu, mandaaazi, samosa, fried chicken, or bhajias?	Chips, maakouda, shfenj (Arabic)/ beignet (French), fried vegetables, fried aubergines, fried fish or fried seafood?	Mandaazi, bagia, French fries, fried cassava, fried sweet potato, fried chicken, deep fried pork, or deep fried beef?	French fries, fricasse, brik, bambaloni or ftayer, deep fried fish, deep fried chicken?
25 Fluid milk	Milk, tea with milk, or powdered milk?	Lait or Nido?	Fresh milk, powdered or packaged milk, milk tea, or milk in porridge?	Milk, coffee with milk?
26 Sweetened tea/ coffee/ milk drinks	Tea with sugar, coffee with sugar, Milo or cocoa?	Tea with sugar, coffee with sugar, or Nesquik?	Sweetened tea, sweetened coffee, Milo, or cocoa?	Tea with sugar, coffee with sugar, chocolate drinks such as Chocoline?
27 Fruit juice	Fruit juice or fruit drinks?	Fruit juice, fruit drinks, Assiri, Raibi Jamila, or syrup?	Fruit juice or fruit drinks?	Fruit juice, fruit drinks?
28 SSBs (sodas)	Soft drinks such as Coca-Cola, Fanta, or Sprite, or energy drinks?	soft drinks such as Coca, Fanta, Hawaii, or Tops?	Soft drinks such as Coke, Pepsi, Fanta, or Mirinda?	Soda, such as, Coca, Fanta, Boga, energy drinks such as, Shark, Black Dog?
29 Fast food	Kenchic, KFC, Burger King, Chicken Inn, Subway, Pizza Hut, or other places that serve pizza or burgers?	KFC, Pizza Hut, McDonald's or Burger King?	Pizza Hut, KFC, Subway, Mary Brown, Mr. Burger, or any other burger place?	KFC, Papa John's, Texas Food, Plan B, other places that serve pizza or burgers?

Appendix 2: Inconsistent choices in risk and time preferences games

See Tables 5 and 6.

Table 5 Inconsistent and consistent responses by country and game

Game	Kenya	Morocco	Tunisia	Tanzania	Average
RP—consistent	249	492	390	331	
RP—inconsistent	259	8	112	170	
RP—total	508	500	502	501	
RP—share inconsistent	0.51	0.02	0.22	0.34	0.27
TP—consistent	355	490	466	380	
TP—inconsistent	153	10	36	121	
TP—total	508	500	502	501	
TP—share inconsistent	0.30	0.02	0.07	0.24	0.16

Table 6 Jointly inconsistent and consistent responses by country

Choice type	Kenya	Morocco	Tunisia	Tanzania	Average
Consistent	214	483	372	278	
Inconsistent	294	17	130	223	
Share inconsistent	0.58	0.03	0.26	0.45	0.33

Appendix 3: Clusters on dietary quality: ancillary information

See Figs. 8, 9 and Table 7.



Figure 8 Comparison of cluster algorithms and optimal number of groups; analysis on standardised data. Cluster algorithms: partition around medoids (pam), hierarchical clustering by Ward’s method (hclust ward.D2), complete linkage method (hclust complete). Indices: Hubert & Levin C-index, Silhouette

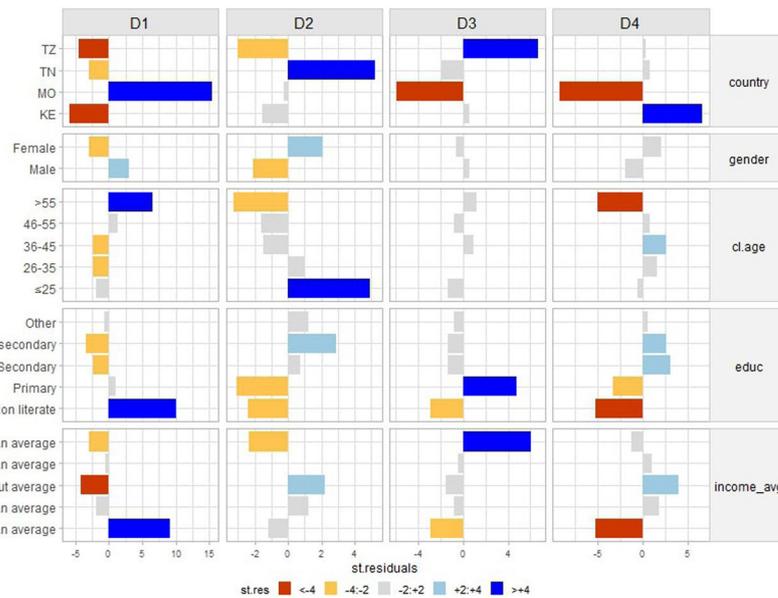


Figure 9 Association plot cluster diet quality clusters versus socio-economic variables

Table 7 Test of relationship between diet quality clusters and selected socio-economic variables

Variable	Test	Statistic	df	p value	Significance level ¹
Country	Chi-square	311.47	9	9.6e-62	***
Gender	Chi-square	13.54	3	0.0036	**
Cl.age	Chi-square	86.83	12	2.0e-13	***
Educ	Chi-square	147.16	12	2.1e-25	***
Income_avg	Chi-square	128.70	12	1.1e-21	***

1. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Appendix 4: Clusters on consumer behaviours: ancillary information

See Figs. 10, 11 and Table 8.

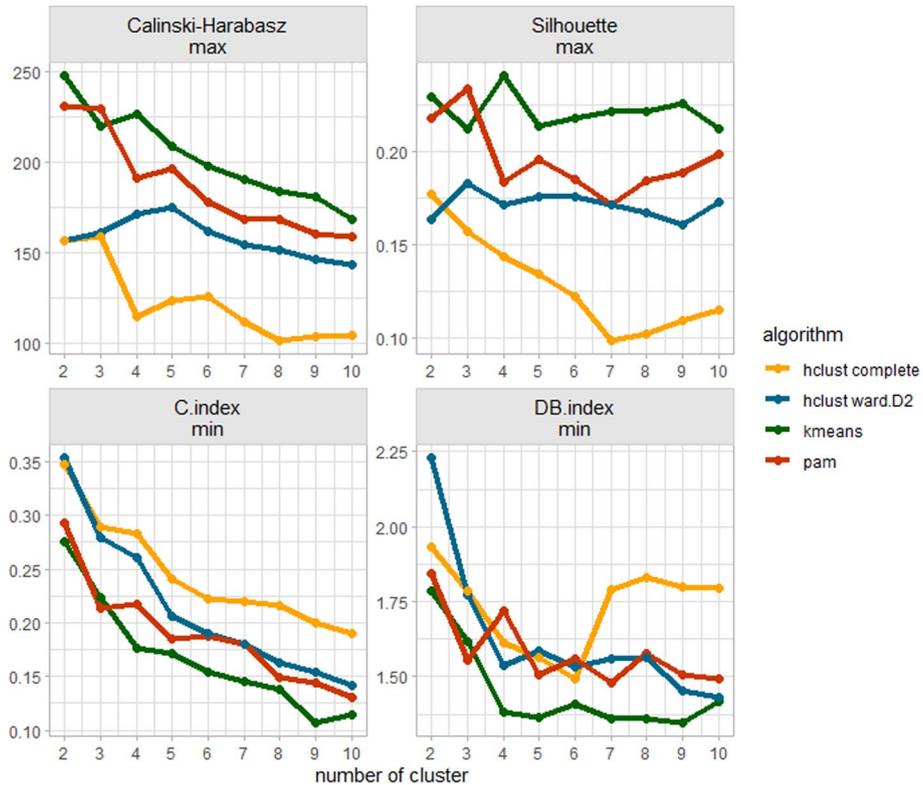


Figure 10 Comparison of cluster algorithms and optimal number of groups; analysis on standardised data. Cluster algorithms: k-means clustering method (k-means), partition around medoids (pam), hierarchical clustering by Ward’s method (hclust ward.D2), complete linkage method (hclust complete). Indices: Hubert & Levin C-index (C), Calinski–Harabasz index, Davies–Bouldin index, Silhouette

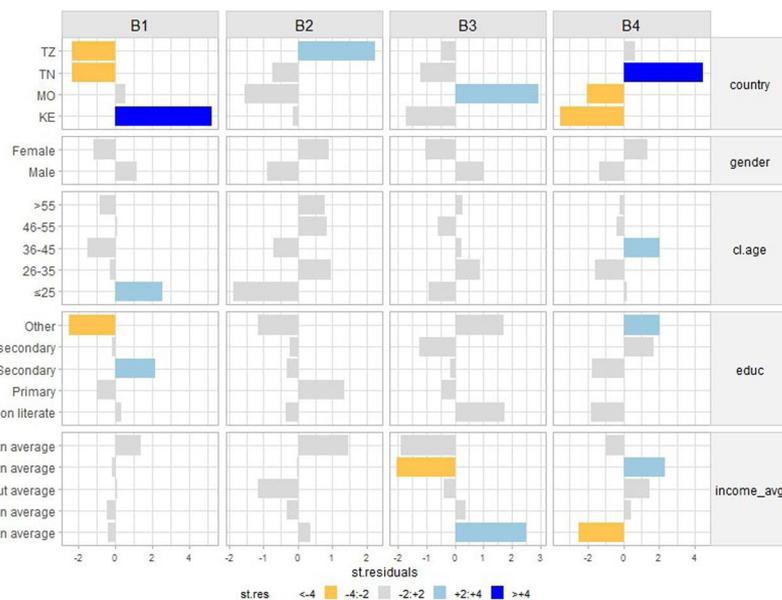


Figure 11 Association plot cluster behavioural clusters versus socio-economic variables

Table 8 Test of relationship between behavioural clusters and selected socio-economic variables

Variable	Test	Statistic	df	p value	Significance level
Country	Chi-square	56.74	9	5.7e-09	***
Gender	Chi-square	3.72	3	0.2929	
Cl.age	Chi-square	14.84	12	0.2506	
Educ	Chi-square	23.01	12	0.0276	*
Income_avg	Chi-square	21.85	12	0.0393	*

1. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Appendix 5: Joint clusters analysis: ancillary information

See Table 9 and Fig. 12.

Table 9 Test of relationship between clusters and selected socio-economic variables

Variable	Test	Statistic	df	p value	Significance level
Country	Chi-square	75.42	9	1.3e-12	***
Gender	Chi-square	4.03	3	0.2585	
Educ3	Chi-square	16.30	6	0.0122	*
Age	Kruskal–Wallis	12.14	3	0.0069	**
HH_size	Kruskal–Wallis	2.97	3	0.3965	
Income_avg	Kruskal–Wallis	9.62	3	0.0221	*
Meet_food_needs	Kruskal–Wallis	25.03	3	1.5e-05	***

1. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

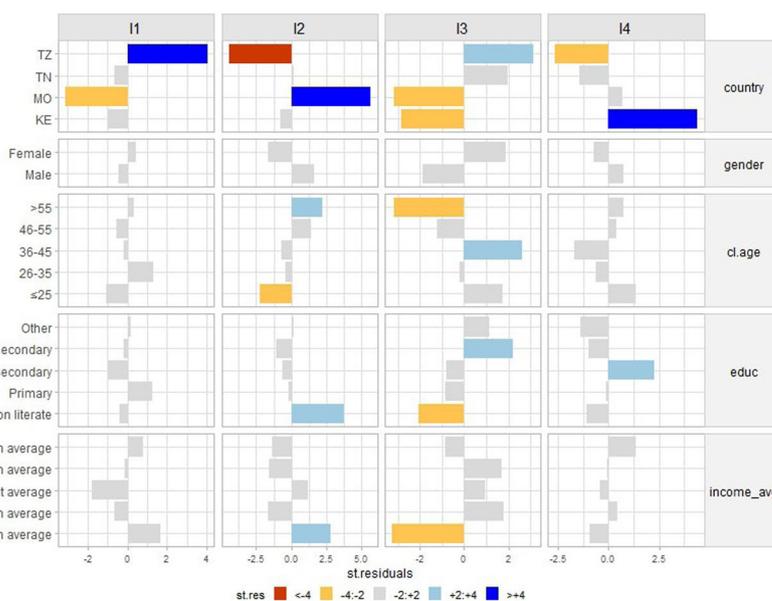


Figure 12 Association plot between joint clusters and socio-economic variables

Abbreviations

FGDS	Food groups dietary diversity score
GDR	Global dietary recommendations score
HDDS	Household diet diversity score
NCD_P	Non-communicable diseases protection
NCD_R	Non-communicable diseases risk
NSVC	Nutrition-sensitive value chains
RP	Risk preferences
TG	Trust game
TP	Time preferences

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s40100-025-00349-7>.

Supplementary Material 1.

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Author contributions

Valentino Marini Govigli was involved in the conceptualization, investigation, writing—original draft, writing—review and editing, and supervision. Fabrizio Alboni contributed to the investigation, methodology, data curation, and visualization. Luca Mulazzani assisted in writing—original draft, and writing—review and editing. Akwilina Mwanri performed the data curation, writing—original draft, and writing—review and editing. Rashid Suleiman contributed to writing—review and editing. Evans Chimoita was involved in the data curation, writing—original draft, and writing—review and editing. Wambui Kogi-Makau assisted in writing—review and editing. Marco Setti was involved in the conceptualization, writing—review and editing, project administration and funding acquisition.

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Availability of data

The data associated with this manuscript are archived in Zenodo: Marini Govigli, V., Alboni, F., Setti, M., & Piras, S. (2023). FoodLAND - Dataset on consumers' food choices, socioeconomic and nutritional conditions, and on experimental results (Version V1) [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.14815113>.

Declarations**Competing interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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