Combating Malnutrition in Africa Through Diversification of the Food System

HealthyDiets4Africa

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1. Introduction

Previously, sub-Saharan Africa (SSA) was essentially known for the predominance of undernutrition—stunting, wasting, and micronutrient deficiencies (1, 2). Overweight, obesity, and the attendant cardiometabolic diseases were nearly non-existent and often regarded as a problem for High-Income Countries (HICs) (2, 3). However, while the prevalence of overweight and obesity in HICs has almost plateaued in recent decades, it is disproportionately rising in SSA (2, 4, 5). The rise in cardiometabolic risks, together with the omnipresent undernutrition, alongside micronutrient malnutrition, presents the so-called *triple burden of malnutrition* that is highly prevalent in SSA. This burden is a serious threat to the health and economic progress of the region (6). Moreover, studies indicate that childhood malnutrition is associated with metabolic risk later in life.

It is reported that the prevalence of overweight and obesity among adults in SSA stands at ~30% and 10%, which is 13% and 6%, respectively, shy of the global prevalence (4, 5). Overweight and obesity are independent modifiable risk factors for cardiometabolic diseases. The prevalence of Type 2 Diabetes (T2D) and its mediators, such as Impaired Glucose Tolerance (IGT) and overweight/obesity, are inexorably increasing with no signs of receding. In 2021, 24 million (4.5%) people in Africa were living with diabetes, contributing to 416,000 deaths. The prevalence of diabetes and IGT in SSA is projected to increase by 143% (55 million) and 107% (reaching 117 million) by 2045, respectively—the highest globally. Similarly, the highest proportion of undiagnosed diabetes (54%) globally is found in Africa (7). Cardiometabolic diseases have been predicted to surpass infectious diseases as the primary cause of morbidity and mortality in SSA by 2030 (8). According to the recent national report on Non-Communicable Disease (NCD) risk factors, 23.9% of adult Ugandans have a BMI ≥25 Kg/m^2 (9). In urban Uganda, over 44% of women of reproductive age are living with overweight or obesity (10). Although Uganda is often hailed as the food basket of Africa, the country continues to grapple with undernutrition and micronutrient malnutrition, highly linked to suboptimal diets. The 2022/2023 Uganda Demographic Health Survey indicates that 26% of the under-5s are stunted, while 9% and 53% suffer from vitamin A deficiency and Iron deficiency anaemia, respectively (11).

1.2 Diet as an underlying cause of suboptimal cardiometabolic health and undernutrition in SSA

Diet is a critical modifiable risk factor for cardiometabolic diseases. In SSA, cardiometabolic dysfunction is exacerbated by the ongoing nutrition transition- a paradigm shift from the traditional diets- the so-called planetary health diets to affluent diets high in saturated fats, salt, and sugar, and often devoid of fruits and vegetables (3, 5). According to the Global Burden of Disease study, diets high in sodium, deficient in fruits, and low in whole grains were shown to contribute to 3 million, 2 million, and 3 million global mortalities, respectively (12). In addition, rapid urbanisation and increased motorised transport in SSA have reduced the physical activity levels of urban dwellers (6). The rapidly progressing urbanisation has coincided with the increase in rural-urban migration, intensifying the nutrition transition (5). Despite the numerous health benefits, consumption of fruits and vegetables remains generally low in Low- and Middle-Income Countries (LMICs) (13-16). Reports indicate that the consumption of fruits and vegetables in SSA is pervasively low, with the majority of the population not reaching the WHO recommendation of at least 400 g per person per day (17) . For instance, 105.5 kg of fruits and vegetables are consumed per person per year in the African region (16). This threshold falls short of the WHO and FAO recommendation of 146 kg/person/year (17). Notwithstanding the rich diversity of Indigenous Fruits and Vegetables (IFV) in Uganda (18), 27% of Ugandans do not consume any fruit or vegetable in a week, while 88% never meet the aforementioned WHO recommendation (9, 10).

1.3 Nutrient supplementation versus dietary interventions: What works?

Specific nutrient supplementations such as omega-3, multimineral (calcium, selenium, and zinc), multivitamins (B vitamins, and folate), and antioxidants (vitamins A, E, C, and beta-carotene) (19-21), have shown promise in alleviating cardiometabolic risks and micronutrient malnutrition. However, the public health scalability, especially in low-resource settings, still poses serious logistical challenges (22). Food/Dietary interventions may offer a more sustainable avenue to address cardiometabolic disturbances, but their application is context-specific and not a “one-size-fits-all” strategy.

Novel diets, such as the Mediterranean diet—still considered the gold standard for optimal cardiometabolic health, are yet to be widely adopted in SSA. The Mediterranean diet has been shown to reduce the risk of stroke by up to 40% and substantially improve blood pressure (23), ultimately leading to a 10% reduction in all-cause mortality (23). A high intake of fruits and vegetables, whole grains, legumes, nuts, and olive oil characterizes the Mediterranean diet. It also limits the intake of red meat, increases fish consumption, and incorporates moderate amounts of red wine. Despite the numerous health benefits of the Mediterranean

diet, it could still be alien to Ugandan communities whose diets are predominantly carbohydrate-based staples. The integration of such exotic diets would require well-designed behavioral change programs. Moreover, the additional cost of such foods further casts doubts on the feasibility of the Mediterranean diet in a Ugandan setting. Other fad diets are premised on rapid weight loss goals with little evidence of their direct contribution to cardiometabolic health. Moreover, the optimal body weight achieved is relatively short-lived and unsustainable (24). The focus on weight loss may make such diets not feasible among the Ugandan communities, where a large body size is still positively perceived as a sign of prosperity and freedom from HIV.

Dietary interventions feature lifestyle modifications premised on optimal dietary intake and physical activity. Such interventions often focus on intentional weight loss through caloric restriction and increased energy expenditure (25, 26). These may include nutritional counseling, food literacy, individualized menu planning, and, more recently, the mHealth techniques. Among patients living with T2D, intentional weight loss interventions such as the Dutch SLIMMER and the US Look AHEAD lifestyle interventions showed that programmed Physical Activity (PA), dietary adjustments – caloric restrictions, and increased fruits and vegetable intake confer favorable cardiometabolic benefits in (25, 26). However, extrapolating such studies from HICs to low-resource countries like Uganda may present several logistical and contextual challenges. For example, in Uganda, large body size is construed as a sign of prosperity and freedom from HIV (15).

As previously mentioned, the culture of fruit and vegetable consumption among Ugandans is poor—taken together, fruit and vegetable consumption is no more than 1.4 servings per person per day. Therefore, increasing fruit and vegetable intake, solely or through composite novel diets, could present a potential strategy to optimize the cardiometabolic health of Ugandans and tackle micronutrient deficiencies. The concept of 'Food Literacy' (FL) has been shown to mediate fruit and vegetable consumption at different social-ecological levels. Food literacy refers to the *"combination of knowledge, skills, and self-efficacy required to evaluate information about food and plan, manage, select, prepare, and eat foods with the ultimate goal of developing a lifelong healthy, sustainable, and gastronomic relationship with food with a prevailing socio-economic, cultural, physical, and virtual environment"*. In brief, FL seeks to improve knowledge, food skills, and self-efficacy to plan, select, prepare, and eat fruits and vegetables (27). However, the FL levels of Ugandans have been investigated and reported to be relatively low at 44%±10.8 (15) and would need to be improved to realize the effectiveness of FL. In addition, FL sessions are difficult to personalize and may not address individual nutritional challenges (28).

Overall, such interventions that border on behavioral change approaches may require significant investment and may be difficult to scale up. For example, focusing on FL requires investment in community-based workshops and social networks, which present both implementational and effectiveness constraints. In terms of implementation, it is noteworthy that the normally long and repetitive group sessions are labor-intensive for the facilitators and participants (28). Another pitfall of behavioral change interventions, especially the group-based ones, is the 'one-size-fits-all messaging, yet individuals present with personal nutritional challenges. This lack of personalization of nutritional advice negatively affects the effectiveness of such interventions. Moreover, dietary advice is often based on threshold messaging following international guidelines. For example, achieving a target of 10,000 steps/day of physical activity or consuming at least 400 g/d of fruits and vegetables, and intake of ~2000 to 2500 kcal/day (29, 30). While such advice may shortly achieve weight control and attendant cardiometabolic benefits, its sustainability over a long time raises questions. These large lifestyle changes are not only more challenging to integrate and maintain, but also require more motivation for the public to embrace, and are more prone to weight regain (31). On the other hand, dietary approaches that aim to add a healthy food portion to one's habitual diet rather than completely changing their menu are by far more culturally acceptable (32). Studies show that small healthy food portions, like an incremental 200 g/d of fruits and vegetables, can confer clinically relevant metabolic outcomes (33, 34).

1.4 Can we focus on nutrient-dense, indigenous fruits and vegetables-based novel foods and recipes?

Reports indicate that several of Uganda's Indigenous Fruits and Vegetables (IFV) are rich in proteins, dietary fibre, micronutrients, and bioactive compounds with ethnomedicinal properties. Consequently, many of these IFV are locally purported to affect cardiometabolic health positively, and could be harnessed for management and prevention of undernutrition (9, 35-38). Uganda ranks among the top 10 countries with the richest biodiversity globally, with over 18,783 species of flora and fauna (39), including a large diversity of IFV (18, 40). These IFV comprise a diversity of ruderals and conventionally farmed food species whose leaves, fruits, or roots are acceptable and used as fruits or vegetables by communities through custom, habit, and tradition" (41-45). However, despite the claimed benefits, dietary intake of IFV in Uganda remains low (18, 46, 47). Therefore, the main objective of this work was to explore indigenous food species with specific effects on cardiovascular and metabolic health, as well as on the growth and development of young children, and unravel the determinants for their consumption. **Part I** of this report will focus on foods and diets that offer cardiometabolic benefits, while **Part II** will present foods and diets known to support the growth and development of young children.

1.5 Objectives

Hence, the sub-objectives of this work were fourfold;

I. To conduct an inventory, including taxonomic identification of foods with specific health protective effects
II. To determine the bioactive compounds of the identified foods
III. To compose affordable, sustainable, healthy diets for stunted children and obese/overweight adults based on the selected food items
IV. To explore barriers and facilitators for the consumption of these foods

2. Methods

PART I: A focus on foods and diets reputed for cardiometabolic benefits

For objectives **(i), (ii),** and **(iv),** the study followed a mixed-methods research design with a three-pronged approach as presented in the schematic overview, **Figure 1**. The first step focused on conceptualising indigenous foods in the Ugandan context through reviewing grey literature and Delphi rounds with experts. In the second step, we held Focus Group Discussions (FGD), and Key Informant Interviews (KII) to catalogue IFV with potential cardiometabolic benefits and document the barriers and facilitators to consumption. Lastly, we conducted a cross-validation for step 2. Cross-validation included conducting market surveys to assess the IFV's diversity, availability, and pricing. The surveys also aimed to understand the demographics of regular IFV consumers. Further, we performed a phenolic profiling of the identified IFV to gain scientific insight into the potential cardiometabolic benefits. The study was approved by the Uganda National Council of Science and Technology (HS2248ES). It was conducted in compliance with the ethical standards outlined in the Declaration of Helsinki, and all participants provided informed written consent to participate in this study. The study complied with the 1989 International Union for Conservation of Nature guidelines on research involving species at risk of extinction, with special reference to scientific collecting of threatened species.

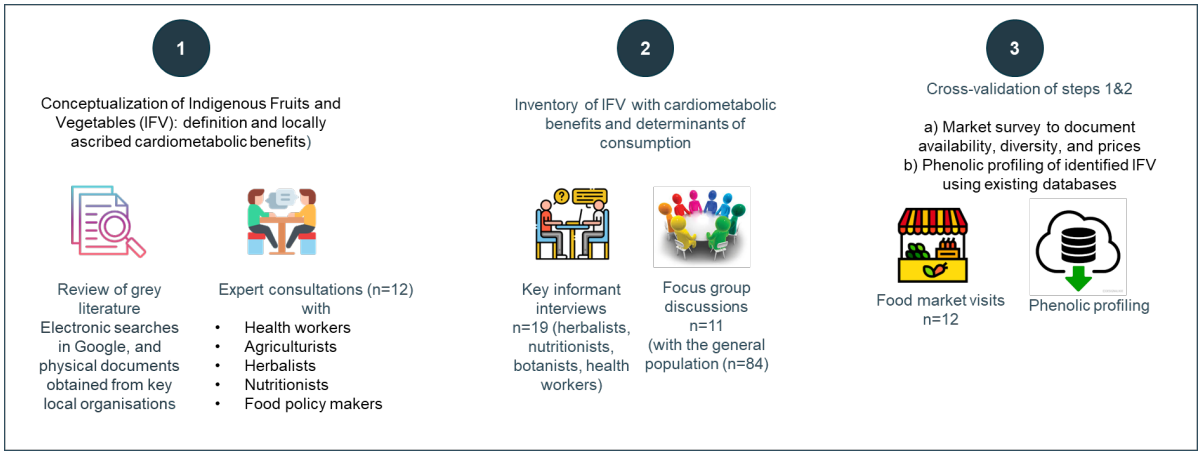

Figure 1: A schematic overview of the different steps followed to conduct the study

2.1. Conceptualisation of indigenous food in Uganda

We reviewed the grey literature on IFV, reputed to have cardiometabolic benefits, in Uganda. A rapid search of grey literature was performed in Google using the following keywords: ('Food system' AND 'Uganda' AND 'environment' AND 'biodiversity' AND 'nutrition' AND 'culture' AND 'traditional knowledge' AND 'rural' AND 'food for traditional medicine' AND 'trade' AND 'wild food' AND 'food for hunger' AND 'neglected plants' AND 'indigenous food'). In this electronic search, organisations that extensively provided material relevant to our study were the Natural Chemotherapeutic Research Institute (NCRI), the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), National Agricultural Research Organisation (NARO), National Council of Traditional Healers and Herbalists Associations (NACOTHA), and the National Environment Management Authority (NEMA). These organisations were physically visited to obtain materials such as reports, theses, magazines, and pamphlets that could not be obtained through electronic searches. Subsequently, in multiple Delphi rounds (48), a panel of 12 experts from the fields of health, botany, herbal medicine, nutrition, and food policy agreed on the definition of indigenous food in Uganda's context, listed examples of IFV, and ascribed cardiometabolic benefits. The agreed-upon definitions were used to validate the FGD and KII responses, and examples of IFV generated were incorporated into the compiled list of IFV.

2.2 Focus Group Discussion and Key Informant Interviews

2.2.1 Study design and participants

The study involved 103 adult men and women (≥18 years) from the Greater Kampala Metropolitan Area (GKMA), regardless of their health status. Eighty-four (84) FGD

participants—30 men and 54 women- were recruited from the general population with the help of community mobilizers, health facilities, and agricultural extension workers. Nineteen (19) Key informants—12 men and 7 women were drawn from NCRI, National Crops Resources Research Institute (NaCRRI), Plant Genetic Resource Centre (PGRC), NACOTHA, Health Services, academia, freelance herbalists, and district agricultural extension services. Participants were recruited via purposive and snowball sampling and were invited to interviews in person by their community health workers. Older adults were intentionally targeted, as it was hypothesised that they would possess a wealth of knowledge regarding IFV and traditional food systems.

2.2.2 Theoretical framework

Food consumption behaviour can be explained by an array of complex interactions of intertwined factors, both at individual and environmental levels, conceptualised through theoretical models (49-51). We used a modified theoretical framework grounded in the Theory of Planned Behaviour and specific constructs from Social Cognitive Theory, the Health Belief Model, the Precaution Adoption Process Model, and social support theory. The modified theoretical framework **(Figure 2)** was necessary because no theory can solely describe a given behaviour (52). The model guided the development of the questioning framework and analysis of KII and FGD. Further details of the development of this modified model have been published elsewhere (53).

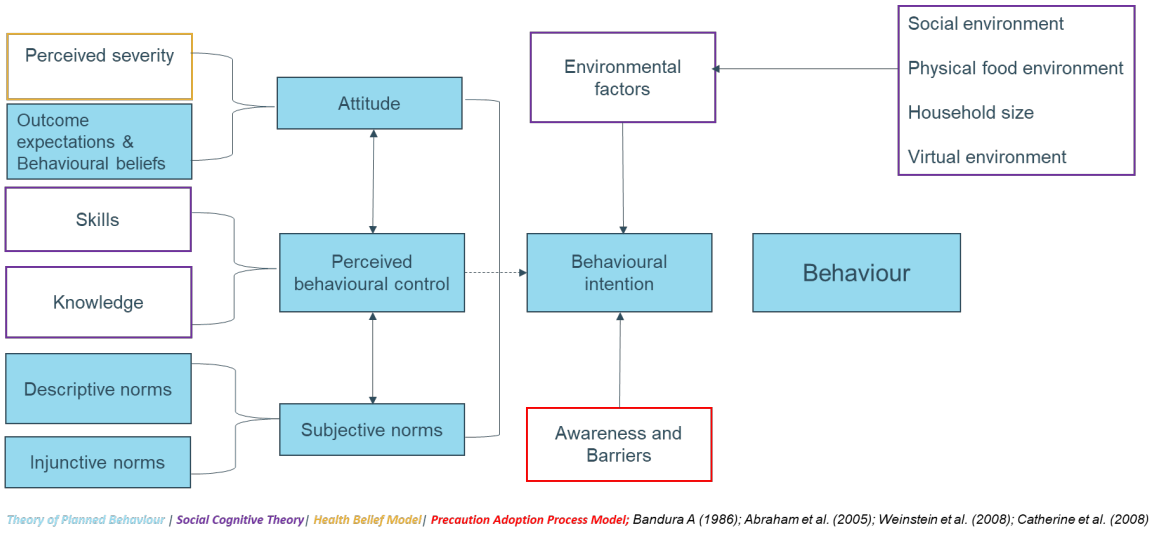

Figure 2: Modified theoretical framework for designing focus group discussion- based on the Theory of Planned Behaviour, Social Cognitive Theory, Health Belief Model, and Precaution Adoption Process Model

2.2.3 Data collection

Using semi-structured questioning, open-ended questions were followed by more specific probes to clarify and extend responses. The discussions were audio-recorded and lasted between 60 and 90 minutes. Before the start of each focus group, the moderator explained to the participants the reasons for conducting the FGD/KII. To elicit age-related perspectives and ensure freedom of expression during the FGD, participants were grouped into two age categories: early adults (18-34 years) and mature adults (≥35 years).

2.2.4 Data analysis

Audio recordings were transcribed verbatim, translated into English for the FGDs and KII conducted in Luganda, and cross-checked by two researchers. Using the thematic content data analysis, two investigators independently read the transcripts and developed the initial coding framework. The framework was discussed among the two researchers to identify similarities and contrasts. In case of disagreements on the coding, a third researcher was consulted. The resulting codebook was used to analyse all the transcripts. NVivo software (version 12.0) was used for the data coding process. Generated codes from all transcripts were organised together into a second coding framework. Codes with overlapping content were grouped into categories. The categories of codes were then grouped into themes using the theoretical framework to generate the final codebook. Two researchers synchronised the final coding frameworks, which were then shared with the third researcher. The inclusion of factors/codes was based on frequency of citation by participants. The non-verbal behaviour and group interactions were equally considered. The interaction of these themes was shaped by three ecological levels, and therefore, findings are reported accordingly:

1. Intrapersonal level: Internal characteristics and psychological elements that influence a person's eating habits. These factors include personal beliefs, attitudes, knowledge, preferences, motivation, and self-efficacy (the confidence in one's ability to make healthy choices). Additionally, they encompass emotions and perceptions regarding food and health.
2. Interpersonal level: Factors influencing eating habits, including age, gender, culture, socioeconomic status, personal preferences, attitudes towards food, psychological and physiological aspects, and social influences.
3. Environmental level: External conditions and elements influence an individual's food choices and eating habits. These include the physical availability of food, whether healthy or unhealthy options are easily accessible. Social influences (family, friends, and cultural norms; economic considerations such as the cost of healthy foods). Other

factors are marketing, advertising, and proximity to food markets. Finally, policies that affect food accessibility and choice shape eating habits.

Both FGD and KII factors are presented together, except where views were divergent. The most commonly used IFV for traditional cardiometabolic therapies were determined by the frequency of citation in both FGD and KII.

2.3 Cross-validation

2.3.1 Market survey

Six open-air food markets and six supermarkets were purposively selected in the vicinity of GKMA. Open-air food markets were Mukono, Seeta, Kireka, Kajjansi, ST. Balikuddembe (Owino) and Nakasero. In addition, a pragmatic sample of three vendors in each market selling at least 10 different IFVs was chosen for a structured interview. The interview themes included pricing, seasonality of IFV, the demographics of the ardent customers of IFV, the variations in sales at different times of the day, storage techniques, and knowledge of potential cardiometabolic benefits of IFV they sell. Further, vendors were asked to report on the customers' perceptions of IFV relative to other exotic fruit and vegetable varieties. Availability of IFV in open-air food markets is reported as the proportion of surveyed food stalls selling a given indigenous fruit or vegetable in each market location. In supermarkets, we recorded all food products that contained indigenous fruits or vegetables, whether as principal products or ingredients in other products, along with pricing, nutrition information, and health claims on the product packaging. A comparison of IFV prices between open-air food markets and supermarkets was not feasible due to substantial variation in weight and form. In addition, we collected data through transect walks in open-air markets and supermarkets to gain a spatially referenced understanding of the availability, diversity, and purchasing patterns of IFV. With the assistance of the market warden, the research team developed a transect diagram to navigate the fruits and vegetables section, taking notes on the parameters of interest. This information would later reinforce the data obtained from FGD, KII, and vendor interviews.

2.3.2 Phenolic, Protein and micronutrient Profiling of the identified IFV

The phenolic profiling was done in two steps. First, we conducted taxonomic classification and verification of local and scientific names of the identified IFV. A herbarium specialist reviewed the compiled list of local names and a photograph of each IFV for taxonomic identification. The specialist also identified the potential availability of additional varieties of the species. The accuracy of scientific names was verified using the International Plant Names Index database (54). In the second step, we searched databases such as Phenol-Explorer (60) and PhytoHub

(61), as well as other publications, to determine the polyphenolic composition of the identified IFV.

PART II: A focus on foods and diets to support the growth and development of young children

2.4.1 Study setting and participants

Makueni County is an arid and semi-arid region in southeastern Kenya, with a population of 987,653 according to the 2019 Kenya National Bureau of Statistics (KNBS). The county is divided into six administrative units, known as sub-counties, which are further subdivided into wards. These wards are then organised into Community Health Units (CHUs), each linked to a health facility where routine growth monitoring is conducted. Data collection took place in five randomly selected health facilities: Kitise, Mavindini, Mbuvo, Kathonzweni, and Kanzokea, all located in Makueni sub-county. The study involved 50 mothers with children aged 6 to 23 months who consented to participate and had resided in the study area for at least two years before the start of the study.

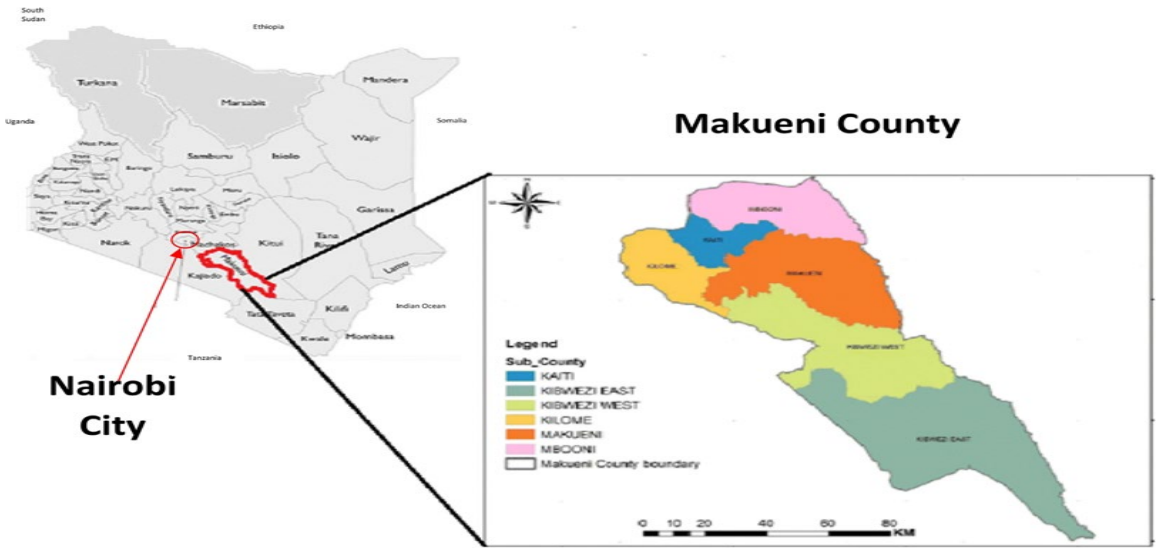

Figure 3: Map of Makueni County

2.4.2 Data collection tool

An FGD guide was used to gather in-depth information on CF practices and their determinants. The discussions were semi-structured and covered the following key areas: Nutrition education and counselling for mothers on IYCF; CF practices, as well as their personal and

physical environmental determinants. The questions were formulated based on insights from Kenyan studies (55-57) and the research team's internal discussions. The FGD guide was pre-tested and modified before being used in the main study.

2.4.3 Data collection procedure

A total of five FGDs were conducted. The focus groups consisted of 8 – 12 mothers each and lasted approximately 60-90 minutes each. Before the start of each focus group, the researcher sought written informed consent from the mothers to record the discussions and take pictures during the discussion sessions. The research assistants collected information on the mother's age, marital status, level of education, occupation, parity, and religion, as well as the child's age. These were recorded in a questionnaire. The discussions were facilitated by a moderator with extensive training and experience in conducting FGDs. The moderator assigned a code to each of the participants for easy identification. The mothers were encouraged to answer the questions freely and in detail. The moderator would ask for clarification and use prompts to collect more information. The moderator also ensured that all mothers had a chance to participate in the discussions. All the FGDs were audio-recorded, and notes were captured by two research assistants. The language of the discussion was either Swahili or Kamba, and this was decided by consensus of the group participants. The study was approved by the Kenyatta University's Ethics Review Committee.

2.4.4 Data Analysis

The audiotapes were transcribed verbatim and then translated into English. After the transcription, the audiotapes were destroyed, and the transcripts did not bear any identifying information. Transcription and analysis started when the first FGD was conducted to identify emerging themes and potential codes. The first author carefully reviewed the transcripts to ensure quality by comparing them with the original recordings and verifying their accuracy against the field notes. This was confirmed by the last author. Data saturation was reached after the fourth FGD. An additional FGD was conducted after data saturation to confirm the themes, and this resulted in a total of 5 FGDs conducted and analyzed. The transcripts were further analyzed using thematic inductive coding in NVivo 14 software. The codes were developed by the first author and cross-checked by the last author. The themes were developed inductively from the codes and were discussed and agreed upon by the study team. The results were summarized and presented in text form to illustrate the findings. The quotes presented in the findings are labelled based on the mother's code (01 to 12) and the health facility where the FGD was conducted.

2.4.5 Protein and micronutrient Profiling of the identified IFV

The protein and micronutrient profiling was conducted with the help of various food composition databases such as Harvest Plus for Uganda, USDA, and the Kenyan database. The main focus was given to micronutrients most essential for child growth and development.

2.4.6 Co-creation sessions for indigenous food-based recipes and community-based culinary workshops in Uganda

Each session involved 12 participants, 3 facilitators, and lasted approximately three to four hours. Two types of sessions were held. One focused on Focus Group Discussions and training, while the other emphasised a participatory approach during the cooking of the “old” and “new” recipes and brainstorming ingredients for upgraded porridges. Primary outcomes included gathering knowledge about childhood malnutrition in the region, improving participants' nutritional knowledge and culinary skills, and encouraging the adoption of IFV-enriched porridge recipes for children as well as other recipes for adults. To recruit participants for the co-creation sessions, we partnered with community-based organizations, notably Yonderlife Africa, which supported the sessions by setting up a “mobile kitchen station” at central meeting points. The group then explored current porridge recipes by discussing and preparing them together. Following this, the discussion moved to the concept of a balanced diet, focusing on the “go, grow, and glow” food groups and recommended complementary feeding practices. To conclude, an assignment was introduced in which mothers were asked to bring a food item available in their household that could be used to enrich porridge in the next session.

Afterwards, we reviewed the current porridge recipes used at home. Building on these traditional recipes, we brainstormed together with the participants, trying to design three enriched porridge recipes. These new recipes combined accessible ingredients to improve nutritional value while remaining realistic and culturally acceptable for regular household use. Mothers, during which we prepared the newly developed porridge recipes together. Throughout the cooking process, we emphasized good cooking practices and achieving the appropriate consistency. Afterwards, tasting sessions were facilitated, followed by a focus group discussion to gather feedback on the taste, acceptability, and overall feasibility of the new recipes. Alongside the complementary feeding-based recipes, participants cocreated and prepared several other recipes based on the available IFV in the community.

3. Work Done

I. We developed a robust, comprehensive, and iterative methodology to map/catalogue IFV and underscore the determinants of their consumption, **Figure 1**. This methodology could be adapted to similar studies elsewhere.

II. We conducted an inventory, including taxonomic identification of indigenous foods with specific health protective effects through FGDs, KIIs, and a review of grey literature.

III. We profiled the phenolic, protein, and micronutrient content of the identified foods using existing databases.

IV. We conducted co-creation sessions with caregivers of children under the age of five to develop recipes using the identified foods. Following these sessions, we organised community-based culinary workshops to demonstrate the preparation of nutrient-dense and innovative dishes derived from IFV. All recipes created during this process were compiled into a recipe book and a cooking guide, which we distributed to caregivers and to national and regional nutrition working groups.

In addition, we developed juice prototypes using tamarind, an indigenous fruit identified for its high polyphenol content. This juice underwent sensory evaluation and was later tested in an exploratory clinical trial to assess its efficacy in modulating cardiometabolic markers in people living with HIV. The results showed promise in optimising blood pressure and lipid metabolism, suggesting that this juice could serve as an adjuvant therapy for cardiometabolic diseases, as well as a healthy food additive to regular meals.

Our next steps will focus on conducting choice experiments to evaluate willingness to pay for these juice products. Together with the colleagues in WP5 – Task 5.1, we are developing a protocol to conduct these experiments in Uganda. Additionally, based on objectives (i) and (ii), we identified two other IFVs—bitter berries and hibiscus—which also have high polyphenol content and are commonly believed to confer therapeutic benefits for cardiometabolic health. We have designed a postprandial study to evaluate these benefits, particularly with respect to glucose metabolism. The study protocol has been registered on ClinicalTrials.gov with registration number NCT07295600.

V. We conducted a qualitative inquiry into the barriers and facilitators for the consumption of indigenous foods through FGD and KIIs in Uganda. Further, we conducted a separate investigation into the determinants of complementary feeding practices in rural Kenya.

4. Results

Part I: A focus on foods and diets reputed for cardiometabolic benefits

After 11 FGD and 19 KII were conducted, no new themes were emerging—this was defined as reaching data saturation. Each focus group consisted of 6 to 8 participants, totaling 84, with an average age of 43. Three out of the 11 FGDs were conducted among younger adults. The socio-demographic characteristics of participants are presented in **Table 1.**

Table 1: Socio-demographic characteristics of participants of both focus group discussions and key informant interviews

Parameter	Participants in FGD (n=84)	Participants in KII (n=19)
	n, %	n, %
Gender		
Male	30 (35.7)	12 (63.2)
Female	54 (64.3)	7 (36.8)
Age		
18-34 years	32 (38.1)	4 (21.1)
≥35 years	52 (61.9)	15 (78.9)
Employment status		
Employed	55 (65.5)	19 (100)
Not employed	29 (34.5)	0 (0)
Marital status[#]		
Single	25 (31.3)	4 (21)
Married	44 (55)	14 (73.7)
Widowed	11 (13.7)	1 (5.3)
Education Level		
None	14 (16.7)	0 (0)
Primary level certificate	23 (27.4)	1 (5.2)
Secondary level certificate	27 (32.1)	1 (5.3)
University/tertiary	20 (23.8)	17 (89.5)
Region of origin		
Central	49 (58.3)	10 (52.6)
Eastern	19 (22.6)	3 (15.8)
Western	10 (11.9)	3 (15.8)
Northern	6 (7.2)	3 (15.8)
Household size		
Single-person household	11 (13.1)	3 (15.8)
Multiple-person household	73 (86.9)	16 (84.2)
Average monthly income ($)	56 [a]	1,191 [b]

KII, Key Informant Interview; FGD, Focus Group Discussion; [#] n=80 for FGD participants (4 participants did not disclose their education background); [a,] n=60 FGD participants (24 participants did not disclose their income); [b,] n=13 KII participants (6 participants did not disclose their income).

4.1 Identified IFV species and the ascribed cardiometabolic benefits

A total of 64 IFV species were identified in **Table 2,** and these were either farmed or gathered from the wild. *Tamarindus indica* Linn. (tamarind), *Cleome gynandra* Linn. (spider plant), *Solanum anguivi* Lam. (bitter berries), *Hibiscus sabdariffa* Linn. (hibiscus) were most

frequently cited IFV used as local therapies for cardiometabolic dysfunction. Table 2: Indigenous fruits and vegetables reported to reduce cardiometabolic risks in Uganda

Table 2: Indigenous fruits and vegetables reported to reduce cardiometabolic risks in Uganda

No	English name	Scientific name	Plant part(s) used	Preparation/preservation methods	Claimed cardiometabolic benefits	Source
1	Pawpaw	Carica papaya	Fruits	Eaten fresh, juiced	Weight management, heart diseases, and diabetes	Cultivated
2	Alligator pepper	Aframomum angustifolium	Fruits	Fruits are eaten fresh or can be crushed, water added, and the mixture is filtered to make a juice	Diabetes, high blood pressure, hypercholesterolemia	Wild
3	Egg plant	Solanum melongena	Fruits and Leaves	The fruits are reduced in size and cooked. The soup and the fruits are consumed. • The leaves are crushed, water is added, and then the solution is filtered. • The leaves are reduced in size, shade-dried, and reduced further to a powder that can be reconstituted with water	Diabetes	Cultivated
4	Rhus	Rhus vulgaris	Fruits	Eaten fresh	Diabetes, hypertension	Wild
5	Amaranthus spinach	Amaranthus dubius	Leaves	Steamed, boiled, and fried	Diabetes, hypertension	Wild and cultivated
6	Amaranthus spinach	Amaranthus spinosus	Leaves	Boiled, steamed	Diabetes, hypertension	Wild
7	Amaranthus spinach	Amaranthus lividus	Leaves	Boiled, steamed	Heart diseases	Wild
8	Pumpkin shoots	Cucurbita maxima	Fruits	Boiled	Reduce cholesterol	Cultivated
9	Cho-cho/Chayote	Sechium edule	Leaves, Fruits	Boiled	Diabetes	Cultivated
10	Cowpea	Vigna unguiculata	Leaves	Boiled, steamed	Antidiabetic and hypocholesterolemic activities	Cultivated
11	African spider herb	Cleome gynandra	Leaves	Boiled, steamed, fried	Diabetes, hypercholesterolemia, high blood pressure	Wild and cultivated
12	Mulberries	Morus rubra	Fruits	Eaten fresh	lower cholesterol, blood sugar, and cancer risk.	Wild
13	Prickly tree hibiscus	Hibiscus diversifolius	Leaves, Flowers	Boiled, dried	Hypertension, diabetes, and lower cholesterol	Wild
14	Tree tomato	Cyphomandra betacea	Fruits	Eaten fresh	Obesity and diabetes	Wild, and cultivated
15	Turmeric	Curcuma longa	Roots	Boiled, dried, powdered	Diabetes, weight reduction	Cultivated

No	English name	Scientific name	Plant part(s) used	Preparation/preservation methods	Claimed cardiometabolic benefits	Source
16	Soursop	Annona muricata	Fruits and Leaves	Fruits are eaten when ripe or reduced, crushed, and expressed to make juice • The leaves are reduced in size, shade-dried, and reduced further to a powder that can be reconstituted with water. • Leaves may also be crushed fresh, mixed with water, and then filtered to make a debris-free solution	Diabetes	Cultivated
17	Amaranthus spinach	Amaranthus graecizans	Leaves	Boiled, steamed	Coronary heart disease	Wild
18	Mangoes	Mangifera indica	Fruits	Eaten fresh/juiced	Diabetes and hypertension	Wild and cultivated
19	Bush candle	Canarium schweinfurthii	Fruits	Boiled	Diabetes and hypertension	Wild
20	Wild Date Palm	Phoenix reclinata	Seeds	The seeds are dried, roasted, and then ground into powder. The powder can be reconstituted with water. Or the seeds may be crushed after drying, without roasting them	Diabetes, high blood pressure	Wild
21	Vine spinach/Malabar spinach	Basella alba	Leaves	Boiled	Diabetes	Cultivated
22	Pomegranates	Punica granatum	Fruits	Eaten fresh	Diabetes and stroke	Wild
23	Tamarind	Tamarindus indica	Fruits, Seeds, Barks, Leaves	Fruits are juiced, and Seeds are powdered	High blood pressure, cholesterol-lowering, and Diabetes	Wild
24	Loquat	Eriobotrya japonica	Fruits	Eaten fresh	Diabetes	Wild
25	Black nightshade	Solanum nigrum	Leaves	Boiled, steamed	Diabetes, hypercholesterolemia, high blood pressure	Wild

No	English name	Scientific name	Plant part(s) used	Preparation/preservation methods	Claimed cardiometabolic benefits	Source
26	Pumpkin	Cucurbita maxima	Fruits	Fruit is reduced in size and crushed. After water is added and the juice is filtered off.	Diabetes	Cultivated
27	Desert date	Balanites aegyptiaca	Fruits	Boiled and dried	Diabetes	Cultivated
28	Scarlet eggplant	Solanum gilo	Fruits	Boiled, steamed	High blood pressure, Diabetes	Cultivated
29	Gooseberry	Physalis peruviana	Fruits	Eaten fresh	High blood pressure	Wild, and cultivated
30	Jack fruit	Artocarpus heterophyllus	Seeds/ fruit	The seeds are dried and crushed into a powder. The powder is reconstituted with water, Eaten fresh	Diabetes, hypertension	Wild, and cultivated
31	Hibiscus	Hibiscus sabdariffa	Calyx, Leaves	Dried, powdered, infusions, sprinkled on tea, juiced	Diabetes, hypertension, dyslipidaemia	Cultivated
32	Java plum	Syzygium cumini	Seeds and fruits	Fruits are cooked and consumed, leaving the seeds behind • The seeds are dried and crushed into a paste. The paste is reconstituted with water and filtered to make a solution	Diabetes, High blood pressure	Wild
33	Chilies	Capsicum annuum	Fruits	Dried, eaten fresh, boiled	Lipid-lowering, antihypertensive, antidiabetic, and anti-obesity	Wild and cultivated
34	Chilies	Capsicum frutescens	Fruits	Dried, eaten fresh, boiled	Lipid-lowering, antihypertensive, antidiabetic, and anti-obesity	Wild, and cultivated
35	Bitter berries	Solanum anguivi	Fruits	Fruits can be crushed, mixed with water, and filtered • Fruits can be dried, pounded into a powder, and reconstituted with water, and then filtered • Fruits can be cooked and eaten	Diabetes, high blood pressure, hypercholesterolemia	Wild, and cultivated
38	African ebony/Jackal berry	Diospyros mespiliformis	Fruits	Eaten fresh	Diabetes	Wild
39	Pigeon peas	Cajanus cajan	Seeds	Boiled	Diabetes	Cultivated
40	Sweet potato leaves	Ipomoea betatas	Leaves	Steamed	Diabetes	Cultivated
41	Hibiscus spp	Hibiscus cannabinus	Leaves	Boiled	Cholesterol lowering	Cultivated
42	Bamboo shoots	Bambusa vulgaris	Leaves	Boiled, steamed, or pasted	Diabetes	Cultivated
43	Guava	Psidium guajava	Fruits	Eaten fresh/juiced	High blood pressure	Wild, and cultivated
44	Wild medlar	Vangueria madagascariensis	Fruits	Eaten fresh	Diabetes	Wild

No	English name	Scientific name	Plant part(s) used	Preparation/preservation methods	Claimed cardiometabolic benefits	Source
45	Bambara nuts	Vigna subterranea	Seeds	Steamed/boiled	Diabetes, stroke, and heart disease	Cultivated
46	Cinnamon	Cinnamomum verum	Leaves and Barks	Boiled	Diabetes, high blood pressure	Wild
47	African basil	Ocimum gratissimum	Leaves	Boiled	Diabetes	Wild
48	Black plum	Vitex doniana	Fruits	Eaten fresh	Diabetes	Wild
49	Jute	Corchorus olitorius	Leaves	Boiled, steamed		Wild
50	Carandas plum	Carissa carandas	Fruits	Eaten fruit	Weight management	Wild
51	Star fruit	Averrhoa carambola	Fruits	Eaten fresh, juiced	Diabetes	Wild
52	African breadfruit	Treculia africana	Fruits	Juiced, eaten fresh	Heart diseases	Wild
53	Scarlet eggplant	Solanum aethiopicum	Leaves	Boiled, steamed, fried	Cholesterol-lowering, diabetes, and high blood pressure	Cultivated
54	Small tomato	Lycopersicon esculentum	Fruits	Boiled	Diabetic neuropathy	Wild, and cultivated
55	Ginger root	Zingiber officinale	Roots	Boiled	Diabetes	Cultivated
56	Mushrooms	Agaricus bisporus	Whole	Steamed/boiled/dried of fresh	Diabetes, dyslipidemia	Wild, and cultivated
57	Passion fruit	Passiflora edulis	Fruits	Juiced, eaten fresh	Lowering blood sugar, heart diseases	Wild, and cultivated
58	Lima beans	Phaseolus lunatus	Seeds	Boiled	Diabetes, overweight, and heart diseases	Wild, and cultivated
59	Okra	Hibiscus esculentus/ Abelmoschus esculentus	Fruits	Boiled	Control inflammation	Cultivated
60	White's Ginger	Mondia whitei	Roots	The roots are crashed, water added and then filtered to make a clear solution • The roots may be chewed directly	Diabetes, hypertension	Wild
61	Avocado	Persea americana	Seeds	The seeds are dried and crushed into a powder. The powder is reconstituted with water	Diabetes, hypertension	Cultivated
62	Cassava leaves	Manihot esculenta	Leaves	Boiled	Diabetes, dyslipidemia, stroke	Cultivated
63	Cocoyam/Taro leaves	Colocasia esculenta	Leaves	Boiled, steamed	Overweight	Wild and cultivated
64	Shea butter tree	Vitellaria paradoxa	Fruits and seeds	Add to food for flavour	Antidiabetic, Antidyslipidemic	Wild

4.2 Barriers and facilitators to consumption of IFV

Altogether, 38 factors and 19 themes were drawn from FGD and KII as barriers and facilitators to the consumption of IFV.

4.2.1 Intra-personal factors

Behavioural beliefs

Psychological and physiological perceptions. Participants reported that IFV are often bland or bitter, and lack the visual appeal compared to fast foods. There was a strong preference for exotic fruits and vegetables due to their reportedly superior sensory characteristics.

"Bitter berries, spider plant, cherry tomatoes.... have a bitter taste, so I wouldn't eat them, I prefer meat, fries, and if you go out, you can't order IFV, you just want to eat tastier fast foods because they even look nice," FGD 9&10, KII 6&11.

Additionally, participants noted that IFV are low in satiety and less desirable for intense activities, which is why energy-dense staples are prioritized.

"We work at a construction site, we dig, these jobs require a lot of energy... We choose posho and cassava to provide energy throughout the day. So, we cannot choose IFV, those indigenous foods can only be snacks or tea accompaniments" FGD 3&8

However, participants involved in sports activities indicated that they regularly eat IFV to boost their performance.

Knowledge of cardiometabolic risks. Participants acknowledged the rising trend of cardiovascular diseases, which they largely attributed to unhealthy eating. However, healthful eating was essentially construed as a moderate intake of fats, soda, and alcohol, with very little attention to fruits and vegetables.

Potential cardiometabolic health benefits. Participants drew a link between the consumption of IFV and the prevention of cardiometabolic risks. The older participants referred to some of the IFV as direct remedies for overweight, diabetes, and hypertension.

"When our parents ate these foods, they lived longer and healthier, but nowadays we see young people with diabetes and heart diseases, overweight. Foods like katunkuma, jjobyo, and

all those bitter vegetables can't allow accumulation of body fat, but young people don't care, all they want fast foods..... we are surely dying" FGD 1, 2&3, KII 1-6, 13-17.

Convenience and time implications: The difficulty in preparation of IFV was heavily cited as an impediment for their consumption. Some indigenous vegetables like lima beans and pigeon peas take a long time to cook, which is an inconvenience, especially in the case of busy schedules. Moreover, participants noted the limited supply of safe ready-to-eat/prepacked IFV.

Nutrition knowledge, and food preparation skills. Vegetables like bitter berries and spider plant were cited as difficult to prepare in a way that makes them palatable. The cited preparation methods included boiling, frying, steaming, grinding, sun drying, and seldom pasting. Participants expressed that traditional methods formerly used to prepare most indigenous vegetables are no longer convenient. Frying has replaced boiling and steaming. Vegetable preparation skills were limited, and vegetables were reported to be cooked for longer periods.

"For us indigenous vegetables are not just simply vegetables, there's a cultural dimension to them. For example, there's a traditional way of preparing them which involves wrapping vegetables in a banana leaf and steaming them on top of the main food, unfortunately, all that is lost now; people use plastic bags and polyester sacks, but mostly they simply fry. This makes me sad", FGD 1, 6, 7&8.

"... the way you prepare them matters. These self-styled herbalists may not understand, but the bioactivity of phytochemicals in food is influenced by processing methods, for example, the effect of heat, pH among other factors, so if these processing conditions are not controlled, the phytochemicals could be affected", KII 4.

Self-efficacy: Equipping meal planners with food preparation skills was identified as a key facilitator for the consumption of IFV. Women, who are essentially the meal planners of households, often lack the food skills to prepare palatable dishes from indigenous vegetables that are deemed unpleasant.

"... I think the focus of sensitization should be on women is because they are the meal planners of the homes, and if they don't know the health benefits of these foods or skills to prepare them in a better way, then we won't eat them", KII 10.

4.2.2 Interpersonal factors

Injunctive norms: IFV were associated with several sociocultural misconceptions**.** For example, IFV were regarded as food for poor and low social class people. Early adults considered IFV a symbol of backwardness, food for older adults, and medicine for certain ailments.

"If the neighbors see you eating katunkuma, cherry tomatoes, jjobyo, nsugga… they will laugh at you saying that the poverty at your house stinks. One day I packed these foods for my children for school, but their peers mocked them, saying they are very poor, backward, and eating medicine for old people", FGD 1.

Participants regarded IFV as a coping strategy for food insecurity.

"…. these are foods we eat when we don't have anything else to eat, as for me, if I see people eating these foods, it's an indication that hunger and poverty have struck", FGD 8

Participants reported certain cultural beliefs where IFV are associated with witchcraft and superstitions or are only consumed during particular cultural ceremonies.

"..... *you see, some fruits like jackfruits are thought to be resting places for ancestral spirits, steamed unripe indigenous bananas and mushrooms are used for cleansing after the birth of twins, jjobyo induces labour pains, while rosary peas are used for love charms. If you eat meat or fish together with yams/yam leaves as vegetables, the yams in your garden will all die",* FGD 3&8.

Some IFV, like bitter berries, spider plant, hibiscus, and black nightshade, were linked to weight loss or prevention of weight gain. Participants expressed a positive perception of large body sizes, which they linked to health, wealth, and prosperity.

"…. those foods can make you lose weight, or if you eat them regularly, or you won't gain weight. I can't imagine myself losing weight; in fact, I always want to add weight to look good because when you lose weight, people think you are poor or have health problems", FGD 1.

Descriptive norms. Participants agreed that there is a strong tradition that leads individuals to primarily consume the food they grew up eating. Typically, the main meal consists of carbohydrate-based staples with a small portion of vegetables. Some IFV were culturally connected to specific tribes, and other tribes are reluctant to consume them.

"In the central here, food is carbohydrate staples and occasionally little vegetables at the side..... but the Luos eat a lot of vegetables, then you have vegetables like malakwang, okra, otigo, which are culturally for the Luos, also the way they cook their vegetables like pasting with pea nuts, Hmmm, all these are alien to our culture", FGD 1&3.

The existence of food taboos was presented as another barrier.

"We have clans in Buganda, and each clan has a totem, so you find some indigenous vegetables like Kkobe, Butiko, and Empindi, which means for the people belonging to these clans, such foods are taboos", FGD 8.

Individuals from higher socio-economic groups are becoming increasingly focused on nutrition for longevity, and this has reportedly driven up the demand for IFV. *"My clients are scared of the raging cardiovascular diseases and are seeking remedies in natural foods, especially these indigenous foods; katunkuma, pomegranates, tamarind, jobbyo... everyone wants to live a longer disease-free life, so I always say why take synthetic food supplements when we have these foods here",* KII 16.

4.2.3 Environmental factors

The environmental factors were influenced by the physical and social aspects of food environments.

Physical food environment. Participants reported scarcity of IFV and the ubiquitous availability of exotic fruits and vegetables in urban areas. The main sources of IFV were open-air food markets, however, the availability and diversity of IFV were reported to be erratic during the day. The food markets were said to be far from residences, yet IFV are almost unavailable in the supermarkets.

"Hmmm IFV are so rare, maybe they exist in villages but here in town, markets rarely have them except very early in the morning or late in the evening. But also, markets are far from us, you need a taxi or bodaboda to reach there, that is already money spent", FGD 2&6.

There is minimal availability of ready-to-eat IFV reportedly because the drive towards processing of IFV is still low. Restaurants do not always prepare IFV, as there is a social preference for fast foods and exotic fruit and vegetable varieties such as apples, grapes, French beans, and watermelons. Most IFV are still gathered as ruderals from the wild and

efforts to conventionally farm these foods are still inadequate. The participants agreed that certain types of fruit and vegetable plants are currently rare or completely unavailable in their area. They mentioned that the ability to cultivate fruit and vegetables is hindered by a lack of land, knowledge of urban or backyard gardening, and access to high-quality seeds.

"We used to collect IFV from forests and swamps where naturally they grow, these places have been cleared for settlement and industrial activities...., now if you want a fruit like Ttungulu you can't find it. Maybe if we had space and seeds, we could grow them at home but it's hard because they aren't adapted to conventional farming conditions", FGD 2-5.

Seasonality of IFV was cited as a key determinant of consumption.

"…. definitely, most of these indigenous vegetables are seasonal and are more available/ accessible during rainy seasons, if they are out of season, usually the prices are so high you cannot afford them", FGD 1, 2&8.

Social food environment. It was discussed that the size and composition of the family, the influence of children and women, and peer influence are key determinants of IFV consumption. In multi-person households, priority was given to presumably more satisfying foods such as carbohydrate staples.

"…we are about seven people in the house, so with the little money we have to spend on food, priority is given to more satisfying foods like posho. You cannot start spending on IFV because they cannot make people feel full", FGD 4.

Participants from single-person households reported often choosing ready-to-eat street foods.

"I am alone in my house, so I choose ready-to-eat street foods like potato chips, sausages, soda…, I can't start cooking or making juice", FGD 10.

Food choices were also dictated by what children liked to eat.

"Children don't like such foods, some think IFV are foods for the mature adults, for example, my children don't eat bitter berries, jjobyo, so it's hard to eat it when they are just looking on, so we end up entirely not buying these foods", FGD 1&3.

Women's role and influence. It was reported that culturally, women are responsible for meal planning and preparation, while men typically do not cook or make decision about what should be cooked and how it should be prepared.

"What the wife cooks is what we eat, in our culture, men don't go to the kitchen or plan what is cooked at home. Women will always cook the way their mothers taught them. Besides, our wives get annoyed when we tell them to prepare vegetables at home because they feel we have become so poor", FGD 8.

Female participants noted that preparing vegetables depends on how much money their husbands allocate for food purchases. Priority is given to animal protein sources like meat and fish, while vegetables are considered only if the funds allow. In urban areas, it was also reported that men largely prefer animal-source foods over vegetables.

"….sometimes you have no choice but to prepare the food that your husband likes, not only considering the health benefits, because if you prepare let's say bitter berries or jjobyo, he will choose not to eat", FGD 1&2

Peer influence. Younger adults cited being influenced by their friends to frequent fast food outlets. The mature adults claimed to learn from each other's dietary aspects, such as reducing intake of fried foods and eating fruits and vegetables regularly.

"…I learned how to vary my dishes and not eat the same food all the time, not to prepare food without greens, to eat some fruits during breakfast from my neighbour, while friends teach us to eat boiled foods instead of frying all the time", FGD 1.

Information environment. Participants reported obtaining information on the cardiometabolic benefits of IFV from herbalists, older adults, testimonies of previous users, and NCD clinics. Younger adults particularly claimed to receive such information through social media. However, participants demonstrated difficulty in verifying the authenticity of the shared information.

"There are so many self-styled herbalists and nutritionists nowadays giving all sorts of health and nutritional advice, promoting some IFV and forbidding others, making all sorts of health claims, it is actually sad that you will also find these baseless claims on some food products in supermarket shelves and our people are not protected from this harmful information", KII 5, 6, 10, 13 &14.

It was noted that adverts on billboards and mainstream media mainly promote fast foods and fizzy drinks.

"...I personally feel our people would make attempts, for example, to drink the juice from let's say hibiscus or tamarind if there was a deliberate effort by the media to promote these foods, but all the adverts you see are promoting soda brands and synthetic drinks", KII 15, 17&18.

Food safety concerns. Participants expressed chemical and microbiological food safety concerns. Chemical food safety concerns included pesticide residues and metal debris in powdered IFV. Indigenous vegetables usually grow as ruderals or are cultivated in polluted areas and are often sold under unhygienic conditions. There were also concerns about the influx of genetically modified fruits and vegetables and questions regarding their safety.

"These indigenous vegetables often grow in very unhygienic places for instance in sewage polluted areas, then you find vendors selling them in very unhygienic conditions, you can imagine a vegetable stall mounted above an open drainage channel", FGD 9.

".... from having our indigenous foods turned into genetically modified variants to the uncontrolled use of all sorts of agricultural chemicals, certainly death is on our doorsteps. Everything is sprayed, even at the point of harvesting", KII 3,4&16.

It was emphasized that traditional drying and storage practices of IFV may expose them to mycotoxin contamination.

"…the way these herbalists and farmers handle these products after harvesting for example, you find them drying hibiscus calyxes, katunkuma or ggobe on bare ground, no quality control on storage moisture or temperature, all this could attract mycotoxins and aflatoxins", KII 5&9

Financial considerations. Participants perceived that IFV are expensive and cannot be prioritized given the limited financial resources.

"Absolutely! without doubt we don't really eat what we want, finances dictate what we choose to eat, we can't spend the little money we have got on fruits and vegetables, and we can only buy energy-dense foods. IFV are quite costly from the market", FGD 1-11

4.3 Cross-validation

Concerning the phenolic composition, the identified IFV demonstrated varying concentrations and a diversity of polyphenol classes. Among the four most frequently mentioned IFVs, *T. indica* L. had the highest total polyphenol content (mg/100g) at 4755, followed by *H. sabdariffa* at 2920, *S. anguivi* at 1710, and *C. gynandra* at 1330. The most abundant flavonoids were flavanols, flavones, flavanones, and anthocyanins, while the primary non-flavonoids included hydroxybenzoic acid, hydroxycinnamic acid, and lignans. **Table 3**. Only 5 types of fresh IFV (Tamarind, Bitter berries, Hibiscus, and Pomegranates) were identified in supermarkets. Mainly, exotic vegetables and fruits could be identified across the surveyed supermarkets. Supermarkets had several products processed from IFV, and these were mainly wines, vegetable powders, tea infusions, juice blends, kombucha, and porridge formulations, essentially from such foods as Hibiscus, Tamarind, Bitter berries, Okra, Amaranthus, Avocado seeds, Pigeon peas, and Pumpkin seeds. The prices of IFV-based products were 3 to 4 times higher than their raw forms.

Only 21 out of the 64 IFV cited during FGD and KII were identified in the open-air food markets. The availability and diversity of IFV varied erratically throughout the day, with peaks in the morning and evening. Hibiscus, Tamarind, Amaranthus varieties, Pigeon peas, and Scarlet eggplant were the most common IFV. Pomegranates, Spider plant, Alligator pepper, and Chayote were scarce, while Java plum, Black nightshade, and Cherry tomatoes were completely unavailable. The interviewed vendors reported that older adults were the most frequent buyers of these foods, while the younger adults were ardent buyers of exotic varieties. Peak sale hours were early morning and late evening. In terms of food handling, no specialised structures were observed, IFV were vended on open stalls with no cooling system, and very often, were exposed to the sun.

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Table 3: Phenolic composition (mg/100g FW) of Uganda's indigenous fruits and vegetables

Name	Total polyphenol content (GAE)	Flavones	Flavonols	Lignans	Flavanols	Flavanones	Hydroxycinnamic acid	Hydroxybenzoic acids	Anthocyanins
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Spinach/ Amaranthus	248.14 (108.29)	1.11 (2.71)	13.74 (31.17)	0.08 (0.03)					
Avocado	152.12 (66.12)			1.01 (0.011)	0.55 (0.41)				
Chilli	158.10 (184.33)	1.89 (1.23)	2.92 (2.63)						
Tomato (cherry)	8.60	3.84 (0.00)	4.56 (5.25)	0.06 (0.009)		3.84 (2.87)	1.01 (0.38)		
Egg plant	6.10 (5.23)			0.11 (0.04)			1.03 (0.17)	1.57 (1.06)	
Tomato	45.06 (16.12)	0.09 (0.50)	1.22 (1.66)	2.86 (2.89)		0.96 (0.43)	3.35(0)	0.07 (0.00)	
Cucumber	20.06 (3.94)	0.002 (0.005)	0.1 (0.23)	3.86 (3.84)					
Pumpkin	109.98 (81.45)	1.63 (0.00)		0.11 (0.079)					
Onion	102.83 (22.31)	0.46 (1.43)	128.51 (110.52)					2.00 (0.00)	9.00 (0.00)
Green bean	31.74 (23.58)		3.57 (1.67)	25.07 (1.42)	2.42 (6.50)				
Black raspberry	980 (0)		19.00 (0.00)					38.00 (0.00)	
Gooseberry	470.14 (156.12)		2.11 (2.00)	0.07 (0.01)	2.11 (0.00)		2.90 (1.27)	1.60 (0.70)	14.00 (0.00)
Lemon	59.80 (31.25)	1.27 (1.17)	0.37 (0.64)	0.02 (0.00)		35.25 (0.21)			
Lime			0.40 (0.00)			46.40 (0.00)			
Orange	278.59 (172.47)		0.10 (0.29)	3.93 (3.88)		44.82 (7.99)			
Dates	484.93 (182.35)			0.16 (0.01)			12.87 (15.08)	3.21 (3.75)	

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Name	Total polyphenol content (GAE)	Flavones	Flavonols	Lignans	Flavanols	Flavanones	Hydroxycinnamic acid	Hydroxybenzoic acids	Anthocyanins
Banana	154.70 (78.74)			0.02 (0.01)	1.55 (4.54)			1.00 (0.12)	
Custard apple					24.94 (0.00)				
Guava	126.40 (0.00)								
Loquat	116.04 (35.60)						79.88 (33.77)	4.66 (2.38)	
Mango	144.77 (109.47)			0.01 (0.0003)	1.72 (0.00)				
Papaya	57.60 (0.00)			0.002 (0.00)					
Ginger	204.66 (14.71)			0.02 (0.00)					
Turmeric	2117 (0.00)								
Medlar					2.72 (0.00)				
Starfruit	142.92 (0.00)								
Pineapple	147.91 (61.33)			0.962 (1.11)					
Passion fruit	57.4 (0.00)			0.02 (0.00)					
Sweet bay (bay leaf)	16.70 (0.00)								
Pomegranate	203.75 (27.19)		0.25 (0.20)	0.30 (0.00)	1.10 (0.00)		0.20 (0.08)	54.97 (77.93)	10.13 (11.14)
Okra	37.14 (3.06)								
Hibiscus	2920.00								
Tamarind	4755.00 (1699.25)								
African spider plant	1330.00								
Bitter berries	1710.00								
Alligator pepper	3552.00 (38.00)								
Black nightshade	1290.00 (80.00)								

Name	Total polyphenol content (GAE)	Flavones	Flavonols	Lignans	Flavanols	Flavanones	Hydroxycinnamic acid	Hydroxybenzoic acids	Anthocyanins
Jack fruit	1,011.00 (32.00)								
Java plum									230.00
Guava	126.40 (0.00)								
Black plum	463.45 (6.85)								8.28 (0.83)
Lima beans	96.00 (0.00)								
Pigeon peas	185.86 (63.28)								
Amaranthus	1010.00 (60.00)								

SD, standard deviation; FW, fresh weight; GAE, garlic acid equivalent

PART II: A focus on foods and diets to support the growth and development of young children.

4.4. Determinants of complementary feeding

4.4.1 Participants' characteristics

The socio-demographic characteristics of the participants are presented in **Table 4**. A total of 50 mothers participated in the study. The majority of the mothers were aged 30 years and younger (66%) with a range from 18 to 42 years. Only 4% were employed (salaried), and slightly less than half had secondary level education and higher (44%).

Table 4: Characteristics of the study participants

Characteristics	n (%)
Age of the mother (years)	
<20	3 (6)
20-30	30 (60)
>30	17 (34)
Age of the child (months)	
6-11	25 (50)
12-23	25 (50)
Marital status	
Single	7 (14)
Married	41 (82)
Widow	2 (4)
Occupation	
Housewife/unemployed	17 (34)
Farmer (working in own farm)	13 (26)
Own business/self-employed	8 (16)
Employed (salaried)	2 (4)
Casual laborer	7 (14)
College student	3 (6)
Level of education	
No formal education	3 (6)
Primary education	25 (50)
Secondary education	17 (34)
Tertiary (college or university)	5 (10)
Parity	
1-2	34 (68)
3 or more	16 (32)

Six themes were developed from the discussions. The themes included who makes decisions about CF, initiation of CF, complementary foods given to children 6-23 months in Makueni,

underutilized foods, determinants of IYCF, and sources of information on CF. The following sections provide a discussion of these themes.

4.4.2 Who makes decisions about complementary feeding

Most mothers stated that they primarily made decisions about the foods given to children under 2 years old.

'It is only the mother who makes the decision. The mother knows what the child needs and likes so the others have no say' (11; Mbuvo CHU)

Some reported that on few occasions, the father would make the decision based on what he could afford to buy from the market.

'Sometimes the father will decide because he is the one who buys the food' (06; Kathonzweni CHU)

Only one mother in all the focus groups indicated that the child's grandmother would sometimes influence what complementary food would be given to children.

4.4.3 Initiation of Complementary Feeding

A few of the mothers reported that they exclusively breastfed their children for six months, then initiated CF after the six months.

'As for me, I breastfed my child for six months without giving anything else. I did not give her even water. Then, from six months, I started giving her porridge' (08; Kitise CHU).

However, several mothers reported that they started giving complementary foods to their children before they reached six months of age. The main reason cited for the early introduction to complementary foods was the perception that the children were not getting enough breastmilk due to inadequate breast milk production by the mothers. They reported that the inability to produce enough breastmilk was as a result of inadequate food intake.

'When we go to the hospital, we are told to breastfeed the children for six months, but the child starts to cry a lot from around three months because of not getting enough. We do that, but we can't be open to the doctor, we lie that the child is only breastfeeding because we don't know what will happen' (04; Kanzokea CHU).

'Not everyone will exclusively breastfeed their child for six months, like me I don't have enough breastmilk, the child would cry a lot, so I started giving her other milk'(12; Kathonzweni CHU).

The mothers reported that thin porridge (made from single cereal flours or flour mixes), cow's milk and diluted goat milk were the first foods mainly given to the infants. They said that the

thin porridge was easy for the child to swallow, while the goat milk was diluted because it was considered to be 'too strong' meaning it had too many nutrients for the child to digest.

4.4.4 Complementary foods given to children 6 to 23 months in Makueni County

At 6 months of age, the mothers reported that they gave children thin porridge made from cereal flour (such as maize flour, millet, and sorghum, commercial flours, and flour mixes from the local shops), cow's milk, and diluted goat milk.

'At 6 months, I gave my child porridge, thin porridge, and milk…… I gave cow's milk or goat milk….I add water to goat milk because it is too strong'(07; Mbuvo CHU).

From 7 to 8 months, the mothers reported to give the children light *ugali* (maize pap), *matoke* (cooked green bananas), tomato soup, rice and cereal based porridge [mainly made from a mixture of flours and other ingredients such as maize, millet, sorghum flours, ground nuts and *omena* (silver cyprinid, known as the Lake Victoria sardine, *Rastrineobola argentea*)]. A few reported that they gave children fruits such as pawpaw. The mothers reported either boiling the food and/or mashing it to make it soft and easy for the children to eat.

'I give my child matoke, I add potatoes and pumpkins, sometimes I add spinach' (11; Kanzokea CHU)

The most common complementary foods given to children between 9 and 12 months were *ugali, matoke*, rice, green grams, beans, spinach, and tomato soup. Fruits such as watermelon, pawpaw, and banana were also fed to the children. The participants reported mostly boiling the food, then either mashed or cut the food into small pieces.

'I boil rice and potatoes, add some liquid oil or blue band, cook very well, and leave some soup, then I mash the food' (01; Kitise CHU).

From 13-23 months, the mothers reported to start giving children family foods such as *ugali*, rice, *matoke*, beans, peas, and vegetables while continuing with breastfeeding. Fruits such as mango, pawpaw, oranges, and bananas were also given to the children when available and accessible. Some mothers also reported giving eggs and meat soup.

'From one year, the child can eat anything as long as it is not hard' (05; Kanzokea CHU)

'When we cook meat, because the child cannot chew the meat, I just give him the soup from the meat.'(09; Mbuvo CHU)

Table 5 describes the complementary foods supplied to children in the study area compared to the feeding recommendations established by the Ministry of Health (MOH) in Kenya.

Table 5: Complementary Foods given to Children in Makueni versus Feeding recommendations by the Ministry of Health, Kenya

	Complementary foods given to children		**Recommendations by the Ministry of Health**	
Age Group	**Type of food given**	**Frequency of feeding**	**Type of food**	**Frequency**
6 months	Thin cereal-based porridge Cow's milk Diluted goat's milk	2 times per day with breastfeeding	Begin with the staple foods like porridge (maize, wheat, millet, sorghum), pureed banana or potato. Porridge - only mix 2 cereals Food should be thick	2 times a day
7-8 months	Light u*gali,* spinach, *matoke*, tomato soup, rice, porridge, milk, fruits like pawpaw, milk	3-4 times per day with breastfeeding	Variety of foods from at least 5 food groups in a day Animal source foods (eggs, dairy, flesh foods), grains, other starch foods, legumes, nuts and seeds, vitamin A rich fruits and vegetables, other fruits and vegetables Giving a baby soup of the food is not the same as giving the food itself. Thicken food as the baby grows older.	3 times a day
9-11 months	*Ugali, matoke,* rice, green grams, beans, spinach, rice, tomato soup, Fruits - banana, watermelon, pawpaw, oranges mangoes, milk	Usually, 3-4 times with breastfeeding	Variety of foods from at least 5 food groups in a day Animal source foods (eggs, dairy, flesh foods) grains, other starch foods, legumes, nuts and seeds, vitamin A rich fruits and vegetables, other fruits and vegetables)	4 times a day (3 meals and 1 snack)
12-23 months	Family foods such as *ugali,* rice, *matoke,* vegetables and fruits except tough foods like maize, meat, black beans	Usually, 3-4 times with breastfeeding	Variety of foods from at least 5 food groups in a day Animal source foods (eggs, dairy, flesh foods) grains, other starch foods, legumes, nuts and seeds, vitamin A rich fruits and vegetables, other fruits and vegetables)	5 times a day (3 meals and 2 snacks)

4.4.5 Underutilized foods

Some foods, such as eggplant, mushrooms, baobab fruit, pumpkin seeds, termites, mulberries, desert date, tamarind, and cassava leaves, were found to be available from either own production, the market, or the wild, but were underutilized. For instance, eggplant was readily available in the market but rarely used to prepare complementary foods. The mothers reported that they did not know the preparation method. Although pumpkin seeds were available, the majority of the mothers said that they were not aware that they were edible.

'….. pumpkin seeds? Are they edible? When I take them out of the pumpkins, I just throw them away. I have never even heard that they can be eaten' (01; Mavindini CHU).

4.4.6 Determinants of Infant and Young Child Feeding Practices

(i) Personal Determinants

Knowledge regarding breastfeeding and CF: Most of the mothers reported that children should be exclusively breastfed for 6 months and should continue to breastfeed until at least 2 years of age. They noted that it was important to follow the recommended CF practices for their children to grow up healthy, have a healthy weight, for proper brain growth, to reduce the chances of illness, and for them to remain active.

'For the child to have good health, you are supposed to do exclusive breastfeeding for 6 months and give the baby a balanced diet' (03; Kitise CHU)

The mothers associated a child's ability to digest food and the risk of diseases as the main reasons why food should not be introduced before 6 months.

'The stomach of the child who has not achieved six months of age is not strong enough to digest food. Also, it can cause the child to be sick, like diarrhea, all the time.'(01; Mbuvo CHU)

Concerning CF, participants reported that children should be started on complementary food from the age of 6 months. They noted that children should be given nutritious foods from different food groups for them to be healthy.

'A child should be given a balanced diet. You are supposed to give a child different food such as fruits, legumes, matoke, protein, and vitamins, not just porridge' (10; Kathonzweni CHU)

Maternal perception and beliefs regarding CF: Mothers reported that they avoid giving certain foods to children less than 2 years. They said that children below 2 years were rarely given meat because of the perception that children cannot chew the tough meat, the fear that the

children might choke, and the lack of equipment to make the meat suitable for children, e.g., meat mincers. Meat was also reported to be unaffordable. When available, the children would mostly be given the meat soup, while a few reported removing small chunks of soft meat using their hands and feeding the children. A few mothers reported chewing meat for the children even though this was not recommended by the health professionals.

'*I can't give meat to my child because she can't chew, and she could choke, unless I chew for her and give it to her. But we were told by the doctors and CHPs that we should not chew for them.' (04; Kathonzweni CHU)*

Most of the mothers also reported avoiding giving eggs to children less than one year old. They believed that eggs could lead to delayed speech and cause allergies in the child.

'Eggs have effects on small children, such as the child can have delayed speech and can bring about allergies' (02; Kitise CHU)

(ii) Physical Environment Determinants

Availability and accessibility of complementary foods: Locally available Foods, especially from own production, were more likely to be used in the preparation of complementary foods. Cereal products such as maize flour and millet flour were the most available and accessible foods from own production and the market. Roots and tubers such as green bananas and irish potato were mostly available in the market and commonly used for CF.

'When I harvest maize, I take it for milling to get maize flour for ugali and porridge. Sometimes I buy the maize from the market and mill it.' (07; Mavindini CHU)

Meat such as beef was rarely accessible due to the high cost in the market. Chickens were reared at home mostly for sale and egg production, but rarely slaughtered for household consumption.

'We have chicken, but most of the time we sell them to get money to buy other food stuff like flour' (07; Kitise CHU)

Animal milk (cows' and goats' milk) was commonly given to children, as this was available at the household level.

'I have a goat that I milk and give the milk to my child, or I mix it with her food' (01; Kanzokea CHU)

Seasonality: The mothers said that the availability and accessibility of fruits and vegetables were highly affected by seasonality. They reported that most of the fruits and vegetables were

inaccessible during off-seasons due to high cost, and this affected their use in CF. For instance, the peak seasons for mangos were the months of December to March, while Oranges were available from the months of June to September. Vegetables such as pumpkin leaves and cowpea leaves were mostly available from own production during January to July.

'During the mango and oranges seasons, there are a lot of fruits to give to children, but after the season, there are no fruits to give children unless you buy, and sometimes there is no money to buy' (03; Mavindini CHU)

The participants reported that tilapia and mud fish were only available during the rainy season but were too expensive, hence rarely given to children.

Poverty and household food insecurity: Most of the participants mentioned that a lack of enough food in the household and a lack of money to buy food were the main challenges they faced during CF. The mothers indicated that a lack of enough food due to poverty and food insecurity led to inadequate food intake and hence inadequate production of breast milk.

'When it comes to a balanced diet, you may find that you don't have money to buy what is required, so you just give the child what is available' (06; Mbuvo CHU)

Access to the market: Some participants indicated that the long distance to the markets affected the kind of food they used in CF.

'Sometimes I could be having that Ksh.10 to buy a piece of watermelon, but the distance to the market is too long. And that is the only place I can buy'(08; Kathonzweni CHU)

(iii) Social determinants

Peer influence: From the discussions, some women alluded that they sought advice on CF from peer mothers.

'The women who have given birth before me know how a child should feed since they have the experience. So, I ask them for advice on what to give my child' (06; Mavindini CHU)

(iv) Technological determinants

Lack of food modification equipment: Most of the mothers raised concerns about the lack of equipment that would make food suitable for child consumption, such as blenders and mincers. The mothers reported that even in the marketplace, such as butcheries, it was difficult to find meat mincers, making it difficult to feed meat to the young children.

'*You see, meat is tough, and when you go to the butchery, they don't sell minced meat because they don't have the equipment to mince meat' (05; Mbuvo CHU)*

4.4.7 Co-creation sessions for indigenous food-based recipes and community-based culinary workshops

Insights from this activity directly informed the design of health facility- and community-based culinary sessions aimed at promoting IFV consumption, **Figures 3, 4, and 5.** A total of 172 participants, across the 14 sessions conducted, including 135 women of reproductive age and 15 facility-based health workers, have been trained using an interactive, participatory approach. These sessions emphasized hands-on cooking experiences, enabling participants to engage directly with traditional recipes enhanced with IFVs. Key outcomes included improved culinary skills, increased adoption of traditional IFV-rich recipes, and enhanced nutritional knowledge sharing among participants. The recipe book created from this work is available in **supplementary file 1**.

Figure 4: brainstorming session on enrichment of traditional porridge recipes suited for complementary feeding

Figure 5: Training of regional health workers on the culinary practices of IFV suited for complementary feeding

Figure 6: Sessions for mothers of reproductive age on the culinary practices of IFV suited for complementary feeding

The protein and micronutrient profiles of the identified IFV are presented in **Table 6.**

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Table 6: Protein and micronutrient profile (per 100g) of the identified indigenous fruits and vegetables

English Name	Scientific Name/botanical name	Plant part(s) used	Protein (g)	Zinc(mcg)	Potassium (mcg)	Magnesium (mcg)	Phosphorus (mcg)	Iron (mcg)	Vit A (IU)
Pawpaw	Carica papaya	Fruits	0.47	0.08	182	21	10	0.25	950
Alligator pepper	Aframomum angustifolium	Fruits	7.18	5.02	2.50	0.42	0.33	17.75	0
Egg plant	Solanum melongena	Fruits and Leaves	0.82	0.12	122	11	15	0.25	0
Rhus	Rhus vulgaris	Fruits	0.66	1.45	544	89.32	276	1.45	0
Amaranthus spinach	Amaranthus dubius	Leaves	2.11	0.88	641	55	72	2.26	2770
Amaranthus spinach	A.spinosus	Leaves	2.86	0.53	558	79	49	2.71	9377
Amaranthus spinach	A.lividus	Leaves	2.86	0.53	558	79	49	2.71	0
Calabash	Lagenaria sicerari	Fruits	0.62	0.7	150	11	13	0.2	16
Cho-cho	Sechium edule	Leaves, Fruits	0.8		125	0.03		0.01	
Cowpea	Vigna unguiculata	Leaves	4.67	0.24	351	62	42	1.09	567
African spider herb	Cleome gynadra	Leaves	4.6	0.54	278	27	42	1.9	217
Mulberries	Morus rubra	Fruits	1.44	0.12	194	18	38	1.85	25
Prickly tree hibiscus	Hibiscus diversifolius	Leaves, Flowers	3.9	0.21	257	52	265	1.7	457
Tree tomato	Cyphomandra betaceae	Fruits	2.1	0.4	133	19	51	1.0	91
Tumeric	Curcuma longa	Roots	7.83	22.9	2525	208	299	55	0.01
Graviola/Soursop	Anonamuricata	Fruits and Leaves	1.0	0.1	278	21	27	0.6	0.0
Amaranthus spinach	A. gracecizane	Leaves	2.46	0.9	611	55	50	2.32	2917
Mango	Mangifera indica	Fruits	0.82	0.09	168	10	14	0.16	1082

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English Name	Scientific Name/botanical name	Plant part(s) used	Protein (g)	Zinc(mcg)	Potassium (mcg)	Magnesium (mcg)	Phosphorus (mcg)	Iron (mcg)	Vit A (IU)
Bushcandle	Canarium schweinfurthi	Fruits	8.2	2.4	627	284	508	3.5	45
Wild Date Palm	Phoenix reclinata	Seeds	0.43	0.09	364	8	30	0.17	3464
Vine spinach	Basella alba	Leaves	3.6	0.5	466	40	56	10.9	184
Pomegrates	Punica granatum	Fruits	1.67	0.35	236	12	36	0.3	0
Tamarind	Tamarindus indica	Fruits, Seeds, Barks, Leaves	0.09	0.02	27	4	2	0.75	0
Loquat	Eriobotrya japonica	Fruits	0.43	0.05	266	13	27	0.28	1528
Black nightshade	Solanum nigrum	Leaves	3.8	0.65	421	41	68	8.6	4
Pumpkin	Cucurbita maxima	Fruits	2.04	0.24	288	44	38	0.58	0
Desert date	Balanites aegyptiaca	Fruits	2.45	0	656	43	62	1.02	10
Garden egg	Solanum gilo	Fruits	1.5	0.16	129	13.5	47	1.5	70
Scarlet eggplant	Solanum gilo	Fruits	0.34	0.2	230	14	25	0.25	40
Gooseberry	Physalis peruviana	Fruits	0.88	0.12	198	27		0.32	290
Jack fruit	Artocarpus heterophyllus	Seeds/ fruit	1.72	0.13	448	29	21	0.23	110
Hibiscus	Hibiscus sabdariffa	Calyx, Leaves	1.54	0.82	236	13	133	2.7	60
Java plum	Syzygium cumini	Fruits	0.72	0	79	15	17	0.19	3
Java plum	Syzygium cumini	Seeds and fruits	0.72	0	79	15	17	0.19	3
Chillies	Capsicum annuum	Fruits	1.87	0.26	322	23	43	1.03	952
Chillies	C.frutescens	Fruits	11.26	5.56	423	18.34	223	0.8	0
Bitter Berries	Solunum anguivi	Fruits	11.26	5.56	423	18.34	223	0.8	0
African ebony/Jackalberry	Diospyrus mespiliforms	Fruits	5.44	0.97	94	92.18	9.96	90.49	0
Pigeon peas	Cajanus cajan	Seeds	7.2	1.04	552	68	127	1.6	67
Sweet potato leaves	Ipomoea betatas	Leaves	2.04	0.24	288	44	38	0.58	0

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English Name	Scientific Name/botanical name	Plant part(s) used	Protein (g)	Zinc(mcg)	Potassium (mcg)	Magnesium (mcg)	Phosphorus (mcg)	Iron (mcg)	Vit A (IU)
Hibiscus spp	Hibiscus cannabinus	Leaves	0.9	2.79	208	51	37	12.1	287
Bamboo shoots	Bambusa vulgaeris	Leaves	3.45	1.46	706	4	78	0.66	1
Guava	Psidium guajava	Fruits	2.55	0.23	417	22	40	0.26	624
Wild medlar	Vangueria madagascariensis	Fruits	1.4	0.4	521	39	36.6	1.1	0
Bambara nuts	Vigna subterranea	Seeds	12.4	0.9	539	60	158	2.5	16
Bay leaf	Laurus nobilis	Leaves and Barks	7.62	3.7	529	120	113	43	6185
African tea basil	Ocimum gratissium	Leaves	3	3.7	30.7	14	39	0.3	264
Black plum	Vitex doniana	Fruits	16.0	0	157	7.0	16	0.2	0.0
Jute	Corchorus olitorius	Leaves	4.65	0.8	559	64	83	4.76	5559
Caradas plum	Carisa edulis	Fruits	0.43	0.09	364	8	30	0.17	3464
Star fruit	Averrhoa carambola	Fruits	1.04	0.12	133	10	12	0.08	61
African bread fruit	Trecuria africana	Fruits	1.1	0.1	490	25	30	0.5	4.0
Scarlet eggplant	Solarium aethiopicum	Leaves	0.34	0.05	230	14	25	0.25	40
Small tomato	Lycopersicon esculentum	Fruits	0.79	0.12	191	10	17	0.57	173
Ginger root	Zingiber officinale	Roots	0.33	0.04	36	4	2	0.28	0
Mushrooms	Agaricus bisporus	Whole	2.16	0.86	354	12	86	1.73	0
Passion fruit	Passiflora edulis	Fruits	0.6	0.1	197	7.0	12	0.1	54
Lima beans	Phaseolus lunatus	Seeds	6.4	0.49	478	38	74	1.51	223
Okra	H.esculentus	Fruits	1.62	0.49	183	40	37	0.52	0.52
White's Ginger	Mondiawhytei	Roots	4.35	3.9	593	532	147	9.82	84
Ovacado	Persea Americana	Seeds	2.0	0.6	599	29	52	0.6	0.0
Cassava leaves	Manihot esculenta	Leaves	3.7	3.1	550	62	72	3.1	519

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English Name	Scientific Name/botanical name	Plant part(s) used	Protein (g)	Zinc(mcg)	Potassium (mcg)	Magnesium (mcg)	Phosphorus (mcg)	Iron (mcg)	Vit A (IU)
Cocoyam	Colocasia esculenta	Leaves	3.3	0.65	508	34	55	2.7	376
Shea butter tree	Vitellaria paradox	Fruits and seeds	3.4	1.0	63.6	18.1	24	3.4	228
pigeon peas	Cajanus cajan	seeds	7.2	1.04	552	68	127	1.6	67
Bambara nuts	Vigna subterranea	seed	12.4	0.9	539	60	158	2.5	16
Millet bread	Panicum miliaceum	seed	11	1.68	195	114	285	3.01	0
Plantain	Musa acuminata	fruit	0.79	0.13	465	32	28	0.58	0
Climbing yam	Dioscorea bulbifera	root tuber	0.07	1.21	224.58	137.8	86.2	7.27	3.8
Elephant ear	Xanthosoma sagittifolium	tuber	3.31	0.23	514	36	81	0.55	1.08
Yam	Dioscorea alota	tuber	1.53	0.34	816	21	55	0.54	138
	Plestranthus esculentus	tuber	1.9	3.5	1721	327	337	50	0.2
Bushyam	Dioscorea odoratissima	root	20.69	0.26	294	25	61	0.7	1.54
Maize	Zea mays	fruit	1.8	0.3	137	18	57	0.3	0
Guinea yam	Dioscorea cayanesis	root	2.5	0.25	104	9.47	43.82	0.3	1.74
Sweet potatoes	Ipomomea betatas	roots		0.13	465	32	28	0.58	0
Climbing yam	Dioscorea bulbifera	root	0.07	1.21	224.58	137.80	86.2	7.27	3.80
Cassava	Manihot esculenta	roots	1.36	0.34	271	21	27	0.27	13
Sorghum	Sorghum bicolor	seed	10.62	1.67	363	165	289	3.36	0

Data extracted from USDA, local food composition databases (Kenya, Tanzania and Uganda), blank=not reported in any of the databases used, 0=Absent

5. Discussion

The findings showed a fair understanding of the interface between the consumption of IFV and the prevention of cardiometabolic risks. Although several IFV were linked to potential cardiometabolic benefits, *Tamarindus indica* L. fruits were the most popular potential adjuvant therapy for cardiometabolic disturbances. Interestingly, the phenolic profile of *Tamarindus indica* L. fruits relative to other identified IFV seems to corroborate purported health benefits. The main hindrances to IFV consumption were financial limitations, convenience and time barriers, food safety concerns, lack of knowledge about food and nutrition, physical environment of food, food skills and self-efficacy, sociocultural norms, and physiological and psychological satisfaction. A cross-check of market availability and variety of IFV revealed a shortage of these food items, both fresh and processed. From a conceptual viewpoint, the study is in tandem with the current National Biodiversity Strategies and Action Plan for Uganda, which seeks to conserve indigenous plant genetic resources (58) by raising awareness of the potential health benefits of these neglected foods. The study generates novel evidence on drivers and barriers to IFV consumption in LMIC settings, a pathway to curbing cardiometabolic risks by emphasizing the so-called planetary healthy diets (3).

5.1 Sociocultural perceptions of indigenous fruits and vegetables

The sociocultural norms—where IFV are regarded as food for the poor or weeds and associated with several myths- are believed to affect consumption. The works of Yiga *et al*., (53, 59) corroborate our findings that vegetables are generally regarded as food for the poor. In addition, it was claimed that consumption of IFV promotes weight loss or hampers weight gain, which is undesirable in many African communities. Findings have revealed a culturally entrenched affinity for large body size in SSA as an indicator of health and prosperity (53, 59). This health-beauty paradox is a potential impediment to the consumption of IFV. In several SSA communities, food consumption relates to many sociocultural practices and connotations that are often restrictive (44, 60, 61).

5.2 Socioeconomic aspects of indigenous fruits and vegetables

Food choices were largely influenced by financial status and convenience rather than health considerations. Although it was widely reported that IFV are particularly expensive, the general fruit and vegetable consumption culture among Ugandans is far from optimal (9, 14-16). While it is tempting to assume that a good financial status would predict healthful eating, our findings corroborate earlier reports from Uganda (53), and Tanzania (62) that a higher financial status

may instead trigger unhealthy food choices. Across SSA, a low financial status increases the propensity to consume only carbohydrate staple-based diets, devoid of fruits and vegetables, and ultra-processed foods (59). This seems to invalidate the traditionally ingrained assertion in SSA that vegetables are foods for the poor. Further, some indigenous vegetables take hours to prepare, making them unsuitable in the face of convenience (44). Moreover, the hard-to-cook effect of some indigenous vegetables poses a sustainability challenge through increased demand for fuel.

Physiological and psychological satisfaction is influenced by satiety, food sensory attributes, and peer influence. Findings from SSA show that multi-person households are more focused on providing foods with high satiety and desirability to children (59). Single persons not only presented a propensity to eat out of home but were also more likely to be influenced by their peers to eat fast food. Emotional satisfaction was linked to the consumption of fast foods, while IFV were considered not tasty and visually unappealing even after cooking. In the wake of the nutrition transition, eating from fast food outlets is perceived to be emotionally satisfying, especially for early adults (53). It is imperative to note that the high value attached to energy-dense foods across SSA, compounded by the bitter taste and peculiar colour of IFV are a mainstay hindrance to the consumption of IFV (44, 59). On a positive note, participants reported learning from each other the health benefits of foods like *Solanum anguivi, Cleome gynandra, Tamarindus indica, and Hibiscus sabdariffa* during community group meetings (15). This highlights the importance of community structures as instrumental conduits of nutrition knowledge, and such structures could be harnessed to promote the consumption of IFV.

5.3 Avenues and possible trade-offs to increase the consumption of indigenous fruits and vegetables

Generally, food safety is a key deterrent to the consumption of IFV. In particular, indigenous vegetables are regarded as ruderals growing in polluted places (63, 64). Moreover, there is empirical evidence of the presence of high pesticide residues on Ugandan fruits and vegetables (65, 66). Postharvest handling systems for IFV are still substandard, for example, drying vegetables on bare ground, poor storage, and vending are precursors of food mycotoxin contamination. Particularly, aflatoxin contamination in fruits and vegetables is a rampant threat in SSA (see activities in WP6) (67, 68). Consequently, increased consumption of such IFV introduces another layer of complexity. This delicate balance highlights the necessity for technological and educational intervention to ensure good agricultural practices, safe food processing, and handling practices. Without these measures, efforts to enhance diet quality

could inadvertently pose new health risks, undermining the overall objective of promoting healthy and sustainable diets in SSA.

The claim that IFV have inferior sensory appeal is a salient hindrance to consumption. However, such claims could reaffirm the fact that low food skills and self-efficacy often mediate the exclusion of healthy foods on account of their unpleasant taste (44, 69). Alienating indigenous foods due to their claimed inferior taste has been reported, especially among early adults in South Africa (44). Participants from northern Uganda reiterated that simple innovations, such as pasting with peanut butter, could ameliorate the taste of indigenous vegetables. Such simple innovations to offset unpalatable tastes have also been reported in Ghana (70). While such culinary innovations may enhance palatability, they may increase energy intake, potentially compromising nutritional goals aimed at mitigating diet-related metabolic risks. It has been shown that training sessions built around the concept of food literacy can improve food skills and self-efficacy and consequently increase fruit and vegetable intake (15). Other potentially effective innovations could focus on improving IFV convenience and appeal by stimulating minimally processed 'ready-to-eat' products. Noteworthy, the traditional culinary and preservation practices, where vegetables are customarily steamed for long hours, uncontrolled drying, and roasting, among others, could be detrimental to the integrity of phytochemicals (71, 72).

The scarcity of IFV is a barrier to consumption. Previous studies have documented an apparent lack of healthier food options, such as prepackaged fresh fruits and vegetables in Uganda and SSA (17, 44, 53). For instance, only 62.2 kg and 105.5 kg of fruits and vegetables are available per person per year for Uganda and the entire African region, respectively (16). This threshold falls short of the WHO and FAO recommendation of 146 kg/person/year (17). The scarcity can be attributed to the seasonality of IFV (73), as well as the ubiquitous presence of exotic varieties in the retail food environment (58). The inherent characteristics of IFV, such as low yields and long growth periods, among others, often discourage large-scale production (44, 74, 75). Moreover, there is little doubt that the commercialization of fruits and vegetables has coincided with the desire to cultivate exotic species with superior agronomic qualities (76).

Regarding information on IFV, we observed age-related disparities in the knowledge of IFV. Culturally, the older adults are the custodians of knowledge about indigenous food, which cascades to younger generations over time. However, lifestyle changes marked by rapid urbanisation have caused a shift in nutrition patterns, the so-called nutrition transition (77). Consequently, such indigenous knowledge has plummeted among the early adults (44).

Hence, younger adults were less enthusiastic about IFV in our study. The age-related difference in knowledge of IFV could be critical to developing age-tailored interventions to increase IFV consumption. Participants highlighted that food preparation is traditionally seen as a woman's role. However, promoting community-wide awareness and family-inclusive cooking sessions can help encourage a more equitable sharing of responsibilities.

5.4 Cardiometabolic potentials of indigenous fruits and vegetables

Regarding the nutraceutical potential, the study revealed an array of scientifically unsubstantiated health claims related to IFV. Although *T. indica* L. was widely purported to have putative cardiometabolic benefits, there is a dearth of clinical studies to confirm the claimed efficacy. However, the phytochemical profile of *T. indica* L. shows a wide range of bioactive components such as polyphenols (flavonoids and phenolics), alkaloids, and saponins (78). The abundance of especially polyphenols (flavanols- epicatechins and catechins) is reportedly responsible for the antilipidemic, antidiabetic, hypotensive, and anti-inflammatory properties of *T. indica* L. (79). Based on this study, we conducted a clinical trial that showed that consumption of *T. indica* L. juice could improve lipid metabolism and optimise blood pressure in people living with HIV (80). Further, dietary guidelines for bioactives recommend a daily intake of 400-600 mg of flavanols for cardiometabolic protection (81) while the European Food Safety Authority (EFSA) approved a health claim that 200 mg/d intake of cocoa flavanols is important for vascular homeostasis (82). On the other hand, *H. sabdariffa* L. powder, beverages, or refined extract are gathering a lot of attention, with several epidemiological studies attesting to the cardiometabolic benefits of such food materials (83-85).

5.5 Study strengths and limitations

The study employed a modified theoretical framework to design questioning routes for both KII and FGD. The combination of multiple health behavioural theories has been advocated, as no single theory can solely describe behaviour (52). The use of probes in the questioning route allowed for flexibility in capturing new, emerging themes. The inclusion of food market surveys was an essential component to validate some of the claims from FGDs regarding the availability and diversity of IFV. However, the time of the study could have influenced the findings of the market survey, since seasonal variation has a huge bearing on food availability and diversity (73, 86). Polyphenolic profiling of IFV was not fully complete since a large diversity of IFV have not yet been characterised, and hence unavailable in the databases used.

5.6 Conclusion and recommendations

The consumption of IFV is influenced by a plethora of complex intrapersonal, interpersonal, technological, and environmental factors. At the intrapersonal level, there is a need to enhance food knowledge, skills, and self-efficacy for preparing nutritious meals incorporating IFV through community-based culinary workshops. At the environmental level, there is a need to stimulate the production of IFV by empowering communities with skills in backyard farming. In addition, the food market chain of IFV needs to be streamlined to enhance access to IFV. There is a need to underpin cardiometabolic health claims associated with IFV through clinical trials. The food marketing environment often promotes unhealthy options, so it's vital to implement policies that encourage IFV and limit ultra-processed products. Strategies could include financial incentives like subsidies, support for local producers, and regulatory measures to make IFV more appealing and accessible while disincentivizing unhealthy alternatives.

We developed a robust, comprehensive, and iterative methodology to map/catalogue IFV and underscore the determinants of their consumption. This methodology could be adapted to similar studies in other regions or countries.

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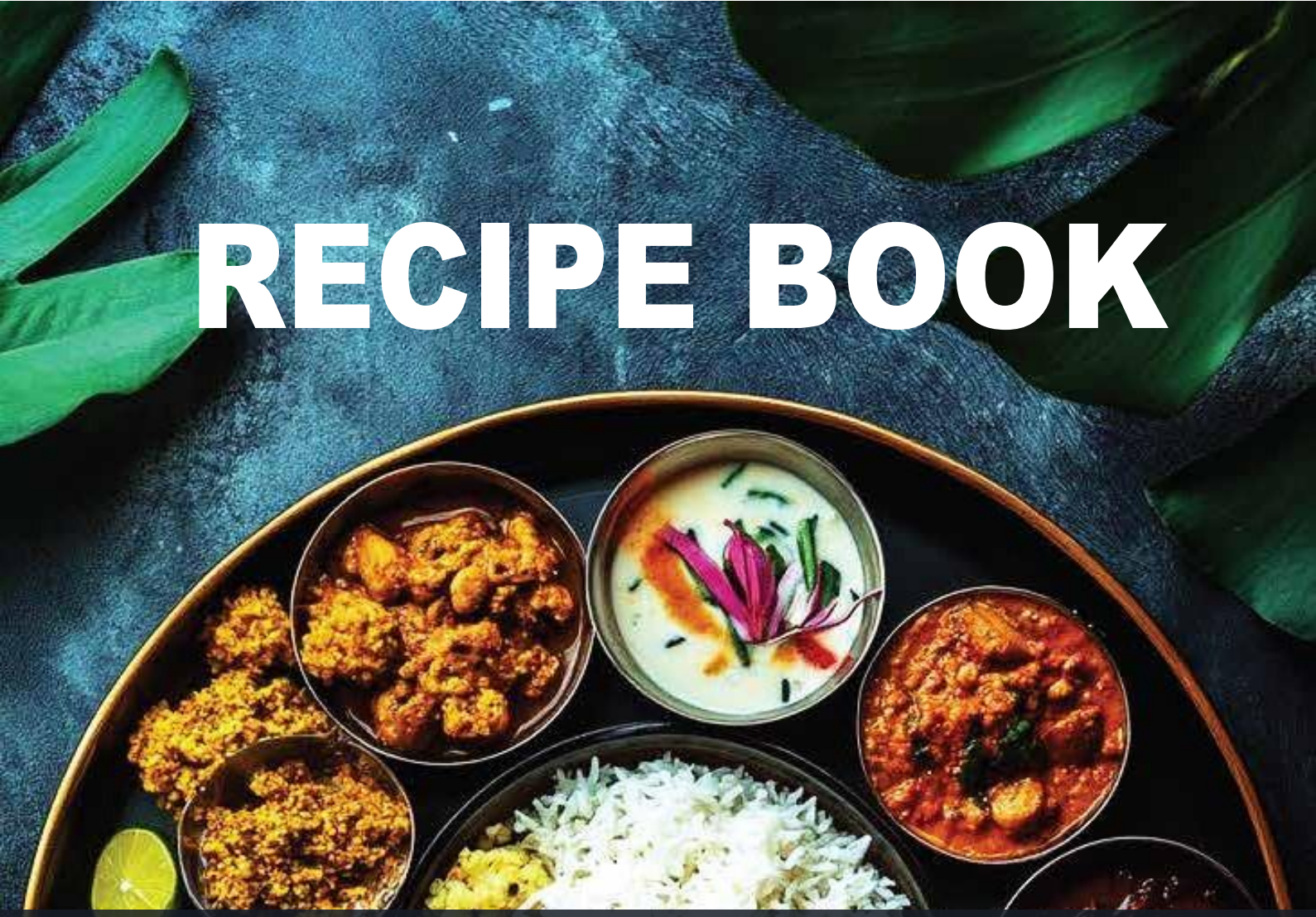
Supplementary file 1 – Recipebook - From Heritage to Haute Cuisine: Enhancing the Sensory Experience of Traditional Ugandan Foods

RECIPE BOOK



"From Heritage to Haute Cuisine: Enhancing the Sensory Experience of Traditional Ugandan Foods."

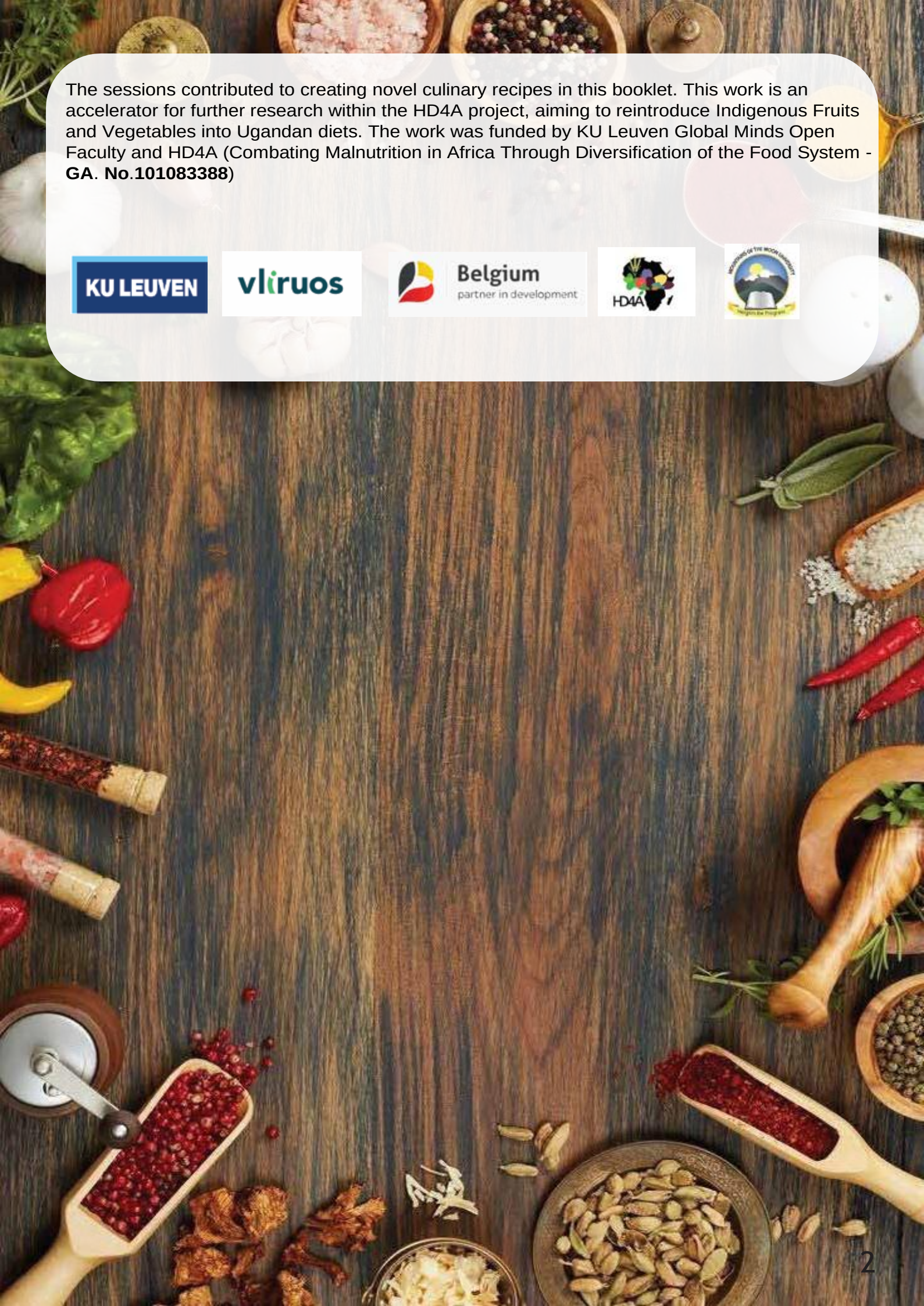
List of Contributors

Katherine Nakatudde, Winnie Nabbanja, Fred Kigozi, Docus Alowo, Lilian Nakayiki Nyanzi, Joshua Wesana, Christophe Matthys and Tonny Kiyimba

Background

The Rwenzori region of Uganda is known as a food basket, with a wide variety of Indigenous Fruits and Vegetables (IFV). Despite this richness, the consumption of these nutrtious foods is low, and this is on the back of high rates of child stunting and micronutrient deficiencies. Additionally, the rising levels of urbanization have led to adverse changes in the food environment—a threat to cardiometabolic health. To address this health dilemma, the Department of Food Innovation and Nutrition at Mountains of the Moon University (MMU), Uganda, in collaboration with the Nutrition & Metabolism Associated Diseases at KU Leuven, Belgium, is working to enhance the culinary skills of the community to promote the consumption of indigenous fruits and vegetables. We partnered with Yonderlife, a community-based organization in Kabarole, to conduct sessions aimed at creating new food recipes that are both delicious and honor the traditional significance of these foods. During our community sessions, we engaged participants in the collaborative creation of new food recipes. Participants provided valuable insights on effective methods for preparing and serving these foods. They discussed strategies for sourcing high-quality ingredients and highlighted traditional accompaniments that enhance the overall dining experience. They emphasized the importance of traditional methods for preparing indigenous vegetables and highlighted the cultural norms that should be observed. With guidance from facilitators at the Department of Food Innovation and Nutrition, participants acknowledged the need to improve traditional culinary practices to enhance the flavor of the food while preserving its nutrients. The co-created recipes were validated through workshops with the nutrition technical working group of the Fort Portal region.

The sessions contributed to creating novel culinary recipes in this booklet. This work is an accelerator for further research within the HD4A project, aiming to reintroduce Indigenous Fruits and Vegetables into Ugandan diets. The work was funded by KU Leuven Global Minds Open Faculty and HD4A (Combating Malnutrition in Africa Through Diversification of the Food System - **GA**. **No**.**101083388**)



RECIPE: MUSHROOM SOUP

Pre-preparation time: 5 minutes / Cooking time: 30 minutes

Ingredients	Amount
Fresh mushrooms	500g
Vegetable cooking oil	2 tablespoons
Onion	1
Garlic	1
Fresh herbes e.g Celery, desired seasonings	1
Water	250ml
Salt	½ teaspoon

PROCEDURE

1. Clean and completely dry the mushrooms
2. Slice mushrooms in desired style
3. Put pan on the fire and add tomatoes and onions. Leave to soften for 2 minutes
4. Add the mushrooms and let them cook without stirring for 3 minutes.
5. Add the water.
6. Add your seasonings at this stage. This can include salt, pepper, garlic, fresh herbs. Cook for 5 to 10 minutes.
7. Remove from the pan and serve.

ALTERNATIVE

Mushrooms can be dried and then added to groundnut sauce. They form an excellent flavorful combination when served with matooke.

Serving size : 4 people

RECIPE: VEGETABLE RICE

Preparation time: 5 minutes / Cooking time: 15-20 minutes

Ingredients	Amount
Rice	500 g
French beans	2 handfulls
Water	500ml
Salt	½ teaspoon
Fresh cowpeas	100 g
Carrot	2 medium size

PROCEDURE

1. Wash and chop the French beans into small pieces
2. Put the rice in saucepan
3. Add the salt
4. Add the water
5. Boil the rice
6. As rice is about to get ready (halfway), pour in the French beans and green peas

ALTERNATIVE

Instead of French beans, you can use carrots, beet root or green peas (already cooked)

Serving size; 4 people.

RECIPE: STEAMED LEAFY GREENS

Preparation time: 5 minutes / Cooking time: 5 minutes

Ingredients	Amount
Leafy vegetables	6 handfuls
Salt	$\frac{1}{4}$ teaspoon

PROCEDURE

1. **Cook on top of matooke or any other food being steamed.**
2. **The vegetables should be put 5 minutes before food is removed from fire.**

Alternative: Ingredients like tomarillo, tomatoes, onions, bitter tomatoes can be added and steamed together.
Portion size : 3 Portions

RECIPE: FRUIT SALAD

Preparation time: 25 minutes

Ingredients	Amount
Mango	1
Tangerines	2
Pawpaw	1
Watermelon	½
Pineapple	½
Apple	2
Guava	2

PROCEDURE

1. **Dice fruits into cubes or rounds.**
2. **Squeeze the passions on top.**
3. **Pour a little syrup over the fruit.**
4. **Optional; dress the fruits in yorghut.**

Use as many fruits as you desire.

Portion size : 3 Portions

RECIPE: FIRINDA

Preparation time: 130 minutes

Cooking time: 50 minutes

Ingredients	Amount
Beans	2 cups (soaked and peeled)
Tomatoes	3 Big ones
Spring Onions	½ Cup
Onions	1
Ground Ginger powder	½ tsp
Salt	½ tsp
Cooking oil	1 tsp
Black pepper	½ tsp
Garlic	1 Clove

PROCEDURE

1. In a pot combine peeled beans with water and let them boil over medium heat for thirty minutes
2. While the beans are boiling, chop the tomatoes, onions and garlic and set aside.
3. Remove the boiling beans from fire. In another pot, pour cooking oil and after one minute, add the salt ginger and garlic
4. Keep stirring to keep from burning. Add onions and tomatoes. Stir for more minutes. Add the beans (with the water used for boiling them) and cover. Let them cook for another 20-30 minutes stirring occasionally till the beans are flaky and tender.
5. Remove from fire. Using a wooden bolle, a pestle or potato mash, mash the soup until it has a creamy consistency. Add the black pepper and sprinkle the chopped spring onions in the soup and serve

Alternative: Egg plants, bitter tomatoes, garden eggs can be added to the firinda while cooking

Portion size : 8 Portions

RECIPE: VEGETABLE MUKENE STEW

Preparation time; 10 minutes | Cooking time; 25 minutes

Ingredients	Amount
Egg plants	3chopped and peeled
Tomatoes	2
Mukene	1 Cup
Onions	1
Fresh Ginger	1 tsp finely chopped
Soy Sauce	1 Table spoon
Cooking oil	2 table spoons
Water	½Cup

PROCEDURE

1. In a cooking pan, pan roast the mukene, set aside
2. In another cooking pan , pour cooking oil, Add salt and ginger while stirring. Add the tomatoes and onions after one minute
3. Keep stirring the tomatoes and onions, cover the pan and let the tomatoes cook until tender. Add the soy sauce
4. Then add the peeled chopped egg plants and stew them for 10 minutes in the pan
5. Open and stir the row thickened paste of vegetables and add the pan roasted mukene and water.
6. Stir and cook for 10 minutes and serve.

Alternative: One can use garden eggs instead of eggplants or both.
Portion size : 6 Portions.

RECIPE: STIR FRIED VEGETABLES

Pre-preparation time: 5-10 minutes / Cooking time: 20 minutes

Ingredients	Amount
Eggplant, diced	1
Onion, peeled and diced	1
Long red chill (or teaspoon chill powder), diced	½
Green pepper, diced	1
Garlic cloves, chopped	2
Medium sized tomatoes	2
Medium sized courgettes	2
salt	½ teaspoon
Olive oil or any other vegetable cooking oil	4 tablespoons

PROCEDURE

1. Dice the eggplant into cubes
2. Add cooking oil to the frying pan or a and heat over medium heat.
3. Add the onions, chili and diced peppers.
4. Cook over medium heat for 2-4 minutes, until well softened.
5. Add the garlic and tomatoes and cook until softened, stirring a couple of times.
6. Add diced courgettes and egg plants and cook for 4-5 minutes while stirring, until slightly browned off.
7. Add a little water and simmer for 5 to 10 minutes.
   You may garnish with fresh parsley if you wish

ALTERNATIVE

Eggplants may be combined with other vegetables and stir-fried, f.e.:

** Eggplants + carrots + tomatoes + onions*

** Eggplants + bitter tomatoes (ntula) + tomatoes + onions*

Portion size : 4 Portions

RECIPE: BAKED EGGPLANT, TOMATOES,ONIONS AND GARLIC MIX

Preparation time: 10 minutes / Cooking time; 30 minutes

Ingredients	Amount
Eggplant, pricked all over with a fork	2
Onion, quartered	1
Garlic cloves, unpeeled	4
Medium sized tomatoes	6
Salt	½ teaspoon
Olive oil or any other vegetables cooking oil	1 tablespoon
Lemon juice	1tablespoon

PROCEDURE

1. Preheat the oven to 180°C.
2. Prick the eggplants,
3. Slice the eggplants in two large pieces
4. Add the eggplants,tomatoes, onion, garlic, cooking oil and salt into a large roasting tin,
5. Use your hands to coat everything well in the oil and salt.
6. Transfer to the oven and roast for 25 to 30 minutes
7. Remove the tin from the oven,the vegetable should be charred all over and very soft when prodded.
8. Remove the garlic, mash the roasted garlic, and mix it with lemon juice.
9. Then sprinkle the mix (dressing) on the vegetable mix
10. Serve warm, with any desired dish

ALTERNATIVE

Instead of eggplants, you can use; carrots, courgettes, bitter tomatoes (ntula), mushrooms etc. or a mix.

Portion size : 3 Portions

RECIPE: PAN-ROASTED BROCOLI

Overall time: 15 minutes

Ingredients	Amount
Brocoli separated into small florets , and stems, sliced	200g
Water	3 tablespoons
Salt	$\frac{1}{4}$ teaspoon
Pepper or any other preferred seasoning	$\frac{1}{4}$ teaspoon
Vegetabke Oil	2 tablespoons

PROCEDURE

1. Stir water, salt, pepper and other seasonings together in small bowl, until salt dissolves.
2. In a frying pan roast the brocoli.
3. Add the broccoli stems
4. Don't stir for about 2 minutes until they get light browned.
5. Add the florets and toss to combine and don't stir for another 2 minutes, until they just begin to brown.
6. Add water spice mixture and cover pan with lid, cooking for 2 minutes.
7. Uncover and cook until desired doneness.

Portion size : 3 Portions

RECIPE: VEGETABLES OMELETTE

Preparation time: 10 - 15 minutes / Cooking time: 5 minutes

Ingredients	Amount
Eggs	3
Small carrot	1
Green pepper	½
Onion	1
Small cauliflower or broccoli (or 1 handful of ebugga)	¼ teaspoon
Black pepper	¼ teaspoon
Salt	¼ teaspoon
Cooking Oil	3 teaspoons

PROCEDURE

1. Slice/grate carrots, cauliflower, broccoli, ebugga, green pepper, onions.
2. Add the vegetables to the bowl.
3. Add the eggs
4. Add the salt and black pepper.
5. Beat/ whip the mixture.
6. Fry the egg.
7. Pour in the egg mixture.
8. Fryuntil ready.
9. Serve with avocado and sliced raw tomatoes.

ALTERNATIVE

You can select a combination of 2 or 3 vegetables according to your preferences

Portion size : 2 Portions

RECIPE: VEGETABLES WITH POTATOES

Pre-preparation time: 5-10 minutes/ Cooking time: 30 minutess

Ingredients	Amount
Medium potatoes, quartered or diced into large cubes	4
Onion, diced	1
Long red chill	1
Stick of celery, diced	1
Large clove of garlic, finely diced	1
Tomatoes	2
Medium carrots, peeledand grated	2
Head of a medium white cabbage, quartered and shredded (core out)	½ medium cabbage
Salt	½ teaspoon
Other seasonings according to preference	
Olive oil or any other vegetable cooking oil	2 tablespoons

PROCEDURE

1. Place potatoes in a small pot of water and season with a pinch of salt.
2. Bring to boil and cook for 10 minutes, until almost cooked. They will
3. finish cooking together with the braised cabbage
4. Heat oil over medium heat in a large pot or a deep frying pan that has a lid.
5. Saute the onions for 2-3 minutes.
6. Add the chilli, celery and carrots saute for 3- 4 minutes, until slightly softened and golden.
7. Add the garlic and cabbage and season with salt and other preferred seasonings.
8. Stir through, cover with the lid and cook for 2-3 minutes. The cabbage will release a bit of juice and reduce in size.
9. Finally, add the diced tomatoes, cooked potatoes and about 1/3 cup of water. Stir throughly and cover with a lid.
10. Cook for 5 to 10 minutes, stirring a couple of times.
11. Finish the dish off by stirring in the fresh herbs.

Portion size : 2 Portions

RECIPE: VEGETABLES SALAD

Overall time: 10 - 15 minutes

Ingredients	Amount
Medium cucumber	2
Medium sized cabbage	¼ medium cabbage
Medium carrot	1
Medium sized tomatoes	3
Apple cider vineger	½ tablespoon
Lemon juice	1 tablespoon




PROCEDURE

1. Wash all the vegetables
2. Remove the leaves from the cabbage, remove the hard stalk
3. Put cabbage in a bowl
4. Cut/grate the cabbage into thin, long straws
5. Blanch grated cabbages in boiled hot water
6. Cut or grate the carrot into thin long straws
7. Add grated carrot to the bowl with cabbage
8. Cut cucumbers like all other vegetables, in thin straws
9. Cut the tomatoes in the same way
10. Mix all the ingredients in a bowl,
11. Mix olive oil, lemon juice, and apple vinegar in a separate container
12. In case you don't have olive oil, lemon juice and apple cider can also give a good taste

ALTERNATIVE

Variations can be prepared by combining different vegetable varieties (carrots, cucumber, tomatoes, onions, cabbage,avocado).They can be eaten completely raw or blanched. Combining different vegetable colors makes the most nutritious salad. They can be eaten exclusively or with an animal protein based food.

Portion size : 4 Portions

RECIPE: BEAN STEW

Preparation time: 10 minutes | Cooking time; 30 minutes

Ingredients	Amount
Beans, cooked and drained	1½ cups
Tomatoes	3
Medium chopped green pepper	1
Onion	1
Garlic cloves	2
Curry powder	½ teaspoon
Cooking oil	2 tablespoons
Salt	1 teaspoon
Bugga/ dodo/ nakati	Handful

PROCEDURE

1. Place the pan on medium heat. Saute and let it heat up.
2. Add onions and garlic in the hot oil, then stir them well.
3. Leave them in the pan until they turn to light brown.
4. Add tomatoes or tomato paste and then stir well.
5. Leave them to cook until they're sort and separate from the oil.
6. Add green pepper, ginger, curry powder, black pepper, cumin, coriander, salt, and stir well.
7. Add beans and a half cup of water to the mixture.
8. Increase the fire and let it boil until the water is almost done.
9. Add the remaining water to the beans and cook under high heat for 15 minutes.
10. Reduce the heat after 15 minutes and let the stew simmer until the water has reduced halfway and it has a creamy oily layer on top.
11. Add the chopped vegetables (bugga, nakati, and dodo) to the stew and boil for 5 minutes before turning down the fire.

Alternative: Any variety of beans can be cooked with the same recipe.
Portion size : 6 Portions

RECIPE: GROUNDNUT STEW

Preparation time: 10 minutes

Cooking time; 30 minutes

Ingredients	Amount
Smooth groundnut paste	7 tablespoons
Medium chopped onion	1
Tomato	1
Salt	1 teaspoon
Bugga/Nyamsiri / dodo/ nakati	Handful

PROCEDURE

1. Using 3 cups of warm water, add the 7 tablespoons of groundnut paste and make a paste
2. Place on medium heat for 1 hour and simmer
3. Add the chopped onions, tomatoes, and salt to the stew and boil for more 30 minutes
4. Add the chopped vegetables, (bugga, dodo/nyamusiri) to the paste
5. Simmer for 20 more minutes and turn down the heat.
6. The stew will be creamy and shinny when ready.

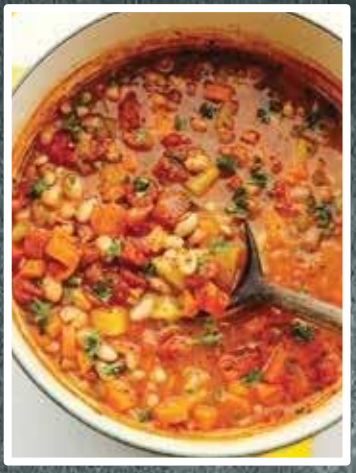
Alternative : **Bugga/Nyamsir/ dodo/ nakati can be substituted with cabbage.**

Portion size : 5 Portions.

RECIPE: COWPEA STEW

Preparation time: 10 minutes Cooking time; 30 minutes

Ingredients	Amount
Cowpea, cooked and drained	1½ cups
Tomatoes	3
Medium chopped green pepper	1
Onion	1
Garlic cloves	2
Curry powder	½ teaspoon
Cooking oil	2 tablespoons
Salt	1 teaspoon
Bugga/ dodo/ nakati	Handful



PROCEDURE

1. Place the pan on medium heat. Add oil and let it heat up
2. Add onions and garlic in the hot oil, then stir them well.
3. Leave them in the pan until they turn to light brown.
4. Add tomatoes or tomato paste and then stir well.
5. Leave them to cook until they're soft and separate from the oil.
6. Add green pepper, ginger, curry powder, black pepper, cumin, coriander, salt, and stir well.
7. Add cowpeas and a half cup of water to the mixture.
8. Simmer the stew until the water is almost done.
9. Add the remaining water to the beans and cook under high heat for 15 minutes.
10. Reduce the heat after 15 minutes and let the stew simmer until the water has reduced halfway and it has a creamy oily layer on top.
11. Add the chopped vegetables (bugga, nakati, and dodo) to the stew and boil for 5 minutes before turning down the fire.

Portion size : 6 Portions

RECIPE: STIR FRIED LEAFY VEGETABLES

Preparation time: 5-10 minutes Cooking time: 5-10 minutes

Ingredients	Amount
Leafy vegetables	6 handfuls
Vegetable cooking oil	1 tablespoon
Onion	1 medium size
Carrots	1 medium size
Green pepper	1 medium size
Water	100 - 200ml
Salt	¼ teaspoon

PROCEDURE

1. Wash, clean and cut the vegetables.
2. Saute the onions and tomatoes. Add carrots, green pepper and other spices as desired.
3. Put in the leafy vegetables and stir until they are well mixed and properly coated with oil
4. Add water, the amount will depend on the type of vegetable being cooked.
5. Dodo will need the least amount ofwater (50ml) while bean leaves and cassava
6. leaves will need about 200ml as they take longest to cook.
7. Serve warm with other dishes

Portion size : 3 Portions

RECIPE: BRAISED SUKUMA WIKI

Preparation time: 5 minutes

Cooking time: 5-7 minutes

Ingredients	Amount
Sukuma wiki leafy vegetable	4 handfulls
Onion	1
Green pepper	1
Egg	1
Black pepper	¼ teaspoon
Salt	¼ teaspoon
Olive oil or any other vegetable cooking oil	1 tablespoon

PROCEDURE

1. Wash Sukuma wiki under running water.
2. Chop the Sukuma wiki, green pepper and onions.
3. Mix the Sukuma wiki, green pepper and onions in a saucepan.
4. Add the seasonings and the cooking oil.
5. Braise the mixture with a lid covered on the saucepan.
6. Beat and add the egg to the mix.
7. Stir for 2 minutes and your dish will be ready to serve.

Portion size : 3 Portions.

RECIPE: PASTED GREEN LEAFY VEGETABLES

Preparation time: 5 minutes Cooking time: 20 minutes

Ingredients	Amount
Groundnut paste	250G
Dodo, bugga, Nakati	4-5 handfulls
Fruits of okra	1-2 or 1bundle of leaves
Magadi / rock salt	¼ teaspoon
	1 teaspoon

PROCEDURE

1. Sort, wash under running water, and chop the leaves
2. Cut the okra and add to the leaves.
3. Boil the water in a pan and add some magadi incase cassava leaves, ggobbe or bean leaves are to be added.
4. When boiling steadily add the greens.
5. Make sure when boiling, water covers the greens.
6. Boil for 15 minutes
7. Remove from fire and drain the cooking water into a container.
8. The greens will be in a wellblended and thick sauce is attained.
9. Add paste to cooked green.s With a wooden spoon or masher blend very well
10. If it is thick, add a little hot water.
11. Add salt and put back on the fire.
12. Stir occasionally and let boil for 15 minutes.
13. Serve hot with millet, posho, sweet potatoes or matooke

ALTERNATIVE

Instead of boo, malakwang, and ggobe, vegetables like ntula, eggplant, sukuma wiki, spinach, nakatti, bugga, dodo, cabbage, pumpkin leaves can be added. These cook for a relatively shorter time.

Drained water from the greens can be used to make other stews.

Portion size : 4 Portions

RECIPE: FRUIT JUICE (MANGO)

Preparation time: 20 minutes

Ingredients	Amount
Big mangoes	2
Water.	

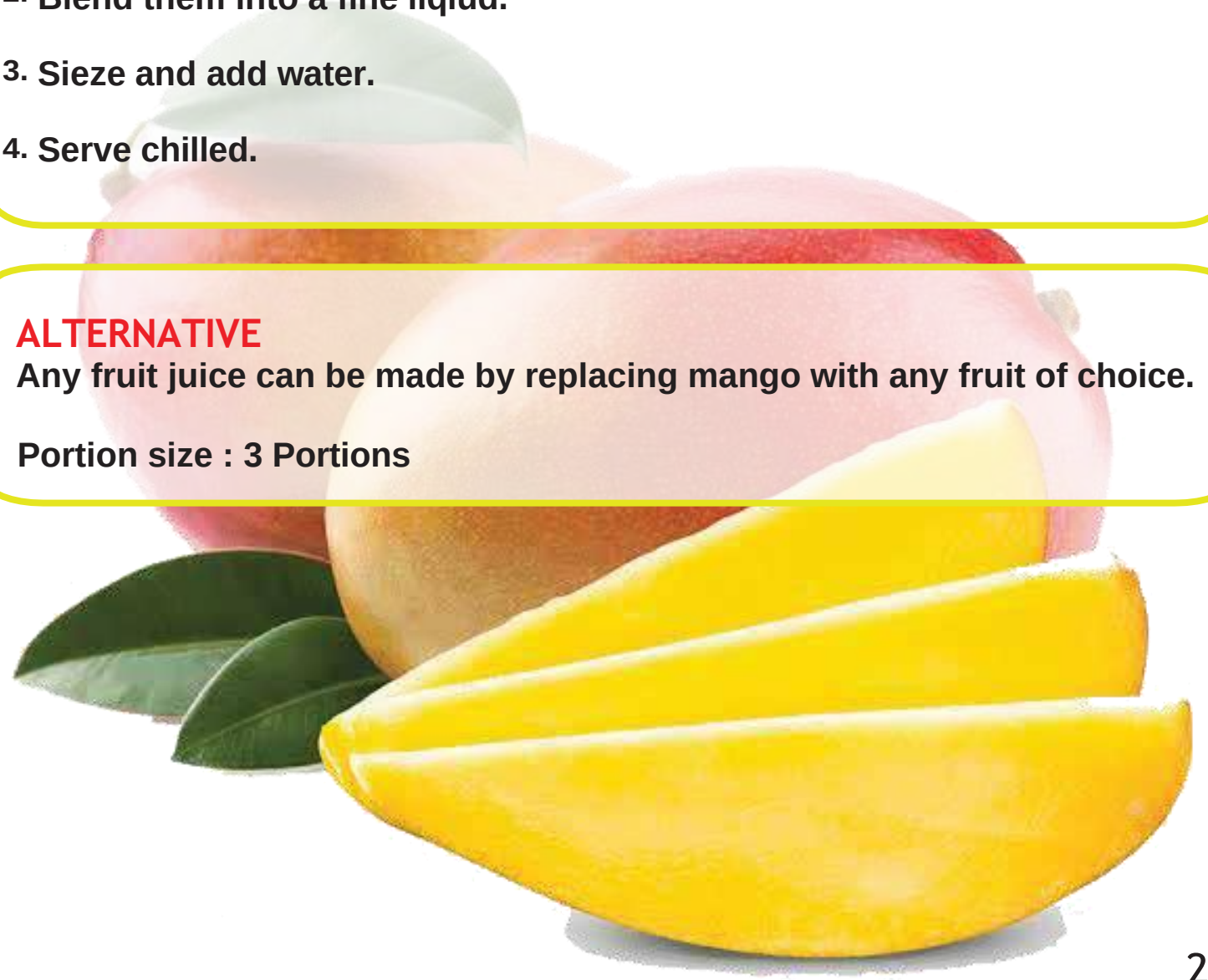
PROCEDURE

1. Peel washed mangoes and dice them.
2. Blend them into a fine liqiud.
3. Sieze and add water.
4. Serve chilled.

ALTERNATIVE

Any fruit juice can be made by replacing mango with any fruit of choice.

Portion size : 3 Portions



RECIPE: COCKTAIL JUICE

Preparation time: 20 minutes

Ingredients	Amount
Mango	1
Tangerines	2
Orange	1
Watermelon	½
Pineapple	½
Passion fruits	2
Water	2 Cups

PROCEDURE

1. Wash fruits and cut them into pieces.
2. Blend the cut fruits with some water.
3. Sieve and add the water.
4. Serve chilled.
5. Use any fruit according to your choice.-

Portion size : 4 Portions

RECIPE: OKRA BEEF STEW

Preparation time: 10 minutes Cooking time; 45 minutes

Ingredients	Amount
Vegetable oil	4 teaspoons
Beef	350g
Chopped green bell pepper	1½ cup
Onion	1
Tomatoes	2
Salt	¾ teaspoon
Cloves of garlic	2 tablespoons
Water	4 cups
Fresh okra pods cut into 1-inch pieces	100g

PROCEDURE

1. Place the pan on fire.
2. Saute the chopped beef in the oil until it has browned
3. Add chopped onions to the beef and cook until brown
4. Add the chopped peppers, garlic, and tomatoes with a little water until soft and creamy
5. Add salt, spices, and 1 ½ cups of water to the sauce and cook for another 15 minutes.

Alternative: Mutton or goats meat can be used.
Other vegetables like eggplants, garden eggs can be cooked with this stew.
Portion size : 3 Portions

RECIPE: OKRA CHICKEN STEW

Preparation time: 10 minutes Cooking time; 45 minutes

Ingredients	Amount
Vegetable oil	4 teaspoons
Chicken	200g
Chopped green bell pepper	1½ cup
Onion	1
Tomatoes	2
Salt	¾ teaspoon
Cloves of garlic	2 tablespoons
Water	4 cups
Fresh okra pods cut into 1-inch pieces	100g

PROCEDURE

1. Heat 4 teaspoons oil in a pan over medium-high heat.
2. Add half of the chicken to the pan; cook for 6 minutes, browning on all sides.
3. Remove chicken from pan. Add remaining chicken to pan; cook 6 minutes, browning on all sides. Remove chicken from pan.
4. Add chopped onions to the chicken and cook until brown
5. Add the chopped peppers, garlic, and tomatoes with a little water until soft and creamy
6. Add salt, spices, and 1½ cups of water to the sauce and cook for another 15 minutes
7. Add the fresh okra pods to the chicken and cook for 20 minutes
8. Once the soup is thick- turn off the fire.

Portion size : 2 Portions

RECIPE: FISH STEW

Preparation time: 10 minutes

Cooking time; 20 minutes

Ingredients	Amount
Vegetable oil	4 teaspoons
Fish	350g
Chopped green bell pepper	1½ cup
Onion	1
Tomatoes	2
Salt	¾ teaspoon
Cloves of garlic	2 tablespoons
Water	4 cups
Fresh okra pads cut into 1-inch pieces	100g

PROCEDURE

1. Add oil to a pan and heat it up.
2. Add the chopped onions to the oil and fry until browned.
3. Add the chopped peppers, garlic, eggplant, and tomatoes with a
4. little water until soft and creamy.
5. Add the fresh/ dry fish to the creamy sauce.
6. Add salt, spices, and 1½ cups of water to the sauce and cook for another 10 minutes.
7. Add the fresh okra pods to the sauce and cook for more 5 minutes.
8. Once the soup is thick turn off the fire and serve.

Portion size : 3 Portions