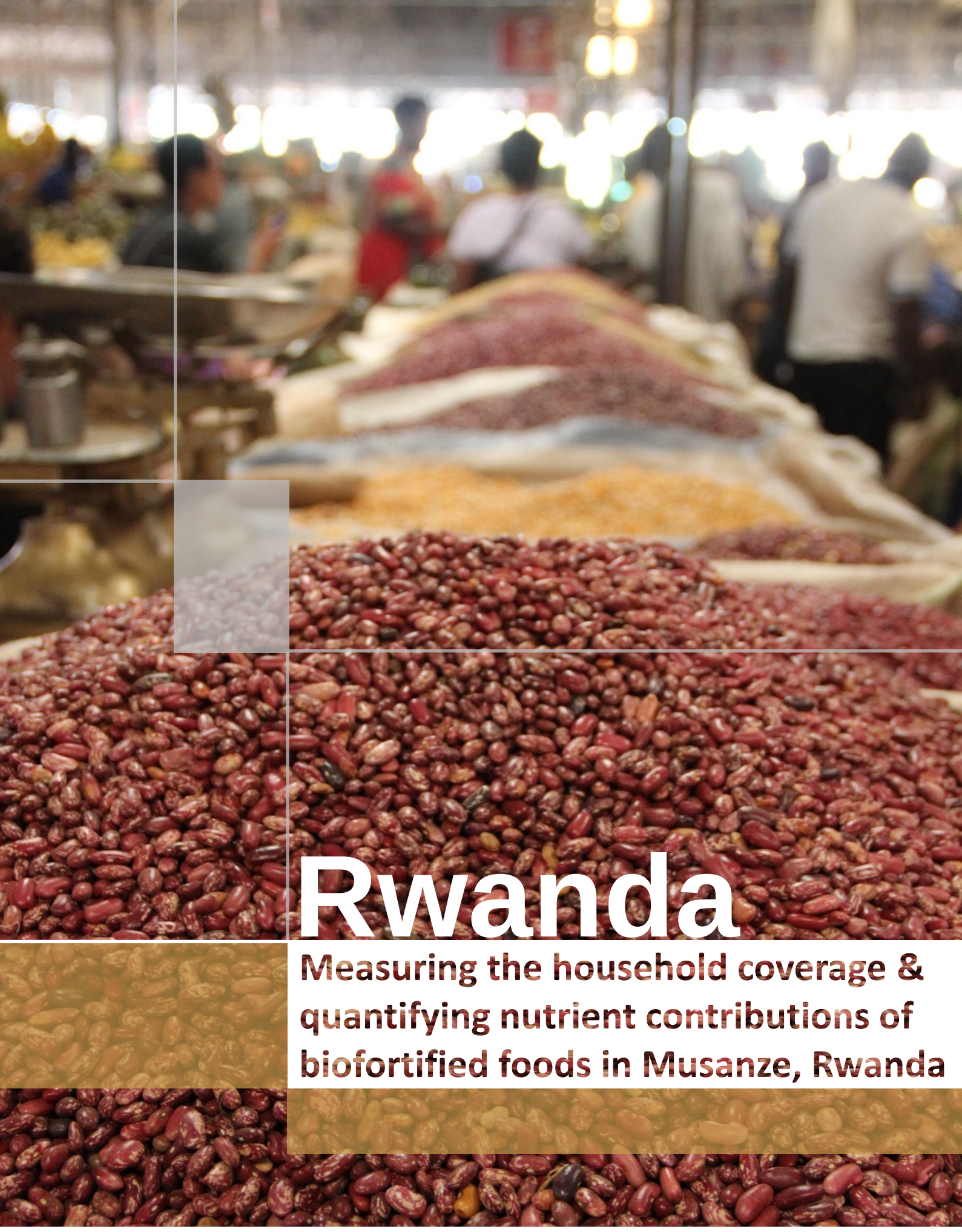

Rwanda

Measuring the household coverage & quantifying nutrient contributions of biofortified foods in Musanze, Rwanda

May 2020

GroundWork
BUILDING GROUNDS FOR NUTRITION & HEALTH

gain
Global Alliance for Improved Nutrition

Measuring the household coverage and quantifying nutrient contributions of biofortified foods in Musanze, Rwanda

FINAL REPORT – May 2020

About GAIN

The Global Alliance for Improved Nutrition (GAIN) is a Swiss-based foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with governments, businesses and civil society, we aim to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable.

About GroundWork

GroundWork is a Swiss-based organization that provides monitoring and evaluation support to large-scale nutrition projects throughout the world. Specifically, GroundWork conducts quantitative and qualitative research and oversees the implementation of large-scale micronutrient surveys and complex intervention studies. By facilitating evidence-based decision making, our goal is to support efforts to improve nutrition and health of populations living in low- and middle-income countries.

Recommended citation

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GroundWork

BUILDING GROUNDS FOR NUTRITION & HEALTH

Sagaci Research
Market intelligence across Africa

UNIVERSITY of RWANDA

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Global Alliance for Improved Nutrition

Collaborating organizations

CIP
INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

HarvestPlus
Better Crops • Better Nutrition

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ABBREVIATIONS

AME	Adult male equivalent
CIP	International Potato Center
EAR	Estimated average requirement
FACT	Fortification Assessment Coverage Toolkit
FGD	Focus group discussions
GAIN	Global Alliance of Improved Nutrition
ICC	Intra-cluster Correlation Coefficient
NPW	Non-pregnant women of reproductive age
ODK	Open Data Kit
OFSP	Orange fleshed sweet potatoes
PSU	Primary sampling unit
RAB	Rwanda Agricultural Board
RE	Retinol equivalent
RNI	Recommended Nutrient Intake
SP	Sweet potatoes

EXECUTIVE SUMMARY

Introduction

Micronutrient deficiencies are a major public health problem affecting large parts of the world's population. While industrial food fortification has successfully reduced the prevalence of micronutrient deficiencies in some countries, many countries contain a sizable proportion of the population that does not consume commonly-fortified foods, such as wheat flour and vegetable oil. Biofortification, the process of enhancing the micronutrient content in plants by plant breeding has been proven to fill the nutrient gap, especially in hard-to-reach populations. Biofortified crops are steadily being introduced, and the scale of many biofortification programs is increasing.

Information on the coverage and consumption of industrially-fortified and biofortified foods is critical to assess the performance and potential for impact of programs and provide information for decision making related to program improvement. There is the need to develop indicators to assess biofortification program coverage that will enable program implementers to identify these critical aspects of program performance.

Objectives

The objective of this study was to develop and test methods for assessing the coverage and consumption of biofortified foods, and their contribution to nutrient intakes of children (6-59 months of age) and women of reproductive age (15 to 49 years) in rural and peri-urban settings. The study site was Musanze District, Rwanda where biofortified beans and orange fleshed sweet potato (OFSP) programs are currently in place.

Additionally, this study aimed to discuss the strengths and weaknesses to the methods developed and make recommendations for future research related to assessing coverage and nutrient contribution of biofortification programs.

Indicator and questionnaire development

Formative research activities (i.e. food market visits, focus group discussions) were conducted to inform the development of the household questionnaire and an impact pathway for biofortification with a suite of coverage indicators based on the coverage indicator framework developed by Tanahashi, and previously used to develop coverage indicators for industrial food fortification programs as part of the Fortification Assessment Coverage Toolkit (FACT). The indicators can be applied independently to specific biofortified foods, and for each specific food capture: 1) consumption of the food; 2) awareness of the biofortified food; 3) availability of the biofortified food; 4) consumption of the biofortified food (ever); and 5) consumption of the biofortified food (current) . Indicator 5 was designed to be objective, with interviewers instructed to a) confirm the presence of a biofortified food (if biofortified food

with visible traits), and b) collect a sample of a biofortified food (if biofortified food with non-visible traits) for inspection by an expert.

Methodology

A cross-sectional household study was undertaken in peri-urban and rural areas in the Musanze District in Northern Rwanda. Twenty-five villages from rural and peri-urban areas in Musanze, serving as primary sampling units (PSUs), were selected with equal probability using simple random sampling. The 25 selected villages were visited, and population lists from each PSU were obtained from village leaders. Using this population information, the number of households was selected based upon proportion of the total population accounted for by each PSU. In total, the study aimed to collect data from 250 households.

The study collected information on household demographics and information related to household accessibility, awareness, consumption and purchase of biofortified foods currently available in Rwanda (high iron beans, orange fleshed sweet potatoes) and other foods that could potentially be biofortified (cassava, maize). Data collection was conducted using tablet computers and open data kit (ODK) software.

We estimated household coverage of biofortified foods using the newly developed coverage indicators, consumption at the household and individual-level (among children and women) using the adult male equivalent method (AME), and nutrient contribution from the food (conventional or biofortified) at the individual level (among children and women) based on the amount consumed and the nutrient level in the foods adjusted for preparation methods.

Results

At the household level, the results indicate that almost all surveyed households consumed beans, and about 65% of the households had ever heard of biofortified beans. Despite high consumption of beans and awareness of biofortified beans, less than one-quarter of households knew where to buy biofortified beans, and only about 15% ever consumed them. Based on visual expert analysis of bean samples collected from nearly 85% of households, about 10% of households purchased biofortified beans the last time they had beans. Importantly, many of the bean samples that contained biofortified beans also contained conventional beans, indicating the either vendor or households mixed beans of different varieties together.

With respect to sweet potatoes, more than 95% of households reported consuming sweet potatoes, and about half of the households had ever heard of orange fleshed sweet potatoes (OFSP). Despite the relatively high awareness, only about 11% knew where to buy them, and about 10% of surveyed households reported ever consuming OFSP. With respect to the last purchase of sweet potatoes, only 2% reported purchasing OFSP, and of these few households, most reported purchasing a mixture of conventions (white) sweet potatoes and OFSP.

Individual-level consumption estimates for beans — conventional or biofortified — show that children 6-59 months of age consumed about 50 grams of beans daily on average, whereas women 15-49 years of age consumed about 120-125 grams daily. Conventional beans contributed 24% and 11% of the RNI for iron among children and women, respectively. The contribution of biofortified beans to iron intakes was naturally higher at about 34% and 19% of the RNI among children and women, respectively.

Only very few households, and subsequently individuals, consumed OFSP. Therefore, results on the consumption and the contribution of OFSP to the nutrient intake will have to be used with caution. Children 6-59 months of age (n=3) consumed about 220 grams and women (n=7) about 640 grams of OFSP on average. OFSP contributed 111% and 590% of the RNI for vitamin A in children and women, respectively.

Discussion

We developed a theory-based coverage cascade for biofortified foods and five universally-applicable indicators to assess the coverage of biofortified foods. The indicators can be used to assess the coverage of biofortified foods with visible and non-visible traits after being adapted to the food of interest. The coverage indicators for biofortified foods directly explore reasons for low consumption of biofortified foods, by examining different aspects of awareness, access, and consumption. The results of the survey show that the indicators enable the estimation of biofortified food coverage and their utility for identifying bottlenecks. Further testing is warranted to confirm the generalizability of the coverage indicators and inform their operationalization when deployed in different contexts.

The adult male equivalent (AME) approach was successful in calculating individual level consumption based on the amount of food purchased/obtained at the household level for biofortified beans. However, we experienced some challenges to reliably estimate the daily household consumption of sweet potatoes, and to a lesser degree, beans. Estimating the consumption based on the last purchased quantities, respondent estimate about how long this purchase lasts, and % of household AME resulted in implausible consumptions in some of the households, especially for sweet potatoes. This is likely due to the fact that sweet potatoes are sold in various different units (e.g. bags, boxes, baskets, etc.), that can have wide ranges in the actual weight of sweet potatoes sold. This presumably made it difficult for some households to estimate the recent quantity of sweet potatoes purchased. In contrast, beans are typically sold by the kilogram in Rwanda, which improved the reliability of the consumption estimates for beans.

Our approach to estimating the contribution of beans to iron intakes among children and women by multiplying the amount consumed by nutrient levels accounting for different levels of bioavailability based on the preparation method of beans worked well. We acknowledge that selecting an RNI is challenging since absorption of minerals from biofortified foods depends on various factors that are hard to predict. Furthermore, it could be challenging for

other crops (e.g. rice, millet) and minerals (e.g. zinc), where there is less evidence related to mineral bioavailability based on cooking/preparation method.

Recommendations

Based on the experience developing this methodology and implementing it in the field, we developed the following recommendations for researchers undertaking future biofortification program assessments.

- **Implement pre-survey activities:** Market vendor surveys and focus group discussions were key to refining the household questionnaire and tools, and their implementation is recommended for future assessments as they can be used a "screening" approach to determine if there is sufficient distribution of the targeted biofortified foods to warrant the implementation of household-based survey.
- **Utilize proportional piling method:** The proportional piling method was used at various times in the Rwanda household questionnaire, and it was well accepted, and provided data that was used directly to estimate individual daily consumption of biofortifiable foods and subsequently, the calculation of %RNI and %EAR. Future assessments should use the method to assess key indicators, such as the proportion of staple food purchased/grown that was biofortified.
- **Sample collection for biofortified foods with non-visible traits:** For future coverage surveys including a target biofortified food with non-visible traits, it is recommended to collect a food sample from each household, and have this sample reviewed by a breeding specialist to determine if each sample is a biofortified or conventional variety. If breeding specialists cannot visibly determine food's variety and ascertain if it is/is not biofortified, laboratory analysis of the sample should be considered.
- **Estimating nutrient contributions:**
    - Use multiple bioavailability values/ RNIs to estimate contribution of iron (and/or zinc) from biofortified foods: Since absorption of iron from biofortified foods depends on various factors and is hard to predict, it is difficult to ascertain what target RNI should be selected. As such, two RNI targets could be used to provide a range of nutrient intake and %RNI.
    - Measure micronutrient concentration in food samples:
      The micronutrient level can vary between different biofortified food varieties. It might therefore be difficult to estimate micronutrient intake and the contribution of the biofortified food to nutrient intakes. Thus, in case the micronutrient level of some of the different biofortified varieties is unknown the micronutrient concentration should be measured quantitatively in some of the collected food samples.

1 INTRODUCTION

Micronutrient deficiencies are a major public health problem affecting large parts of the world's population. They are often referred to as "hidden hunger" as they are often clinically invisible. Iron, vitamin A, iodine, and zinc deficiencies are among the world's most serious health risk factors and substantially contribute to the global burden of disease [1]. It has been estimated that micronutrient deficiencies affect more than 2 billion people. They lead to low work productivity, permanent impairment of cognitive ability, and increased rate of morbidity and mortality [2].

Industrial food fortification has been proven to successfully reduce the prevalence of micronutrient deficiencies over the past decades. It is considered to be one of the most cost-effective and sustainable approaches to deliver minerals and vitamins to large populations [3]. According to the Copenhagen Consensus, food fortification ranks third in terms of international development priorities, and up to 70% of a population could be reached by fortifying staple foods (e.g. wheat flour) with iron and relatively low cost [4]. Despite this progress, many countries contain a sizable proportion of the population that does not consume industrially-fortified foods, such as wheat flour and vegetable oil. Oftentimes, certain populations in developing countries do not have access to conventionally-fortified foods, and subsequently have higher levels of iron, vitamin A, folate and zinc deficiencies [5].

Biofortification, or the development of crops with increased concentrations of bioavailable micronutrients, has been shown to fill the nutrient gap. Through this approach, plant breeders produce crops that efficiently accumulate minerals and vitamins such as iron and pro-vitamin A. When consumed by the general population, biofortified foods increase the intake of key micronutrients, and can be used in all areas (e.g. rural, urban, and peri-urban) but are particularly useful in areas without access to industrially-fortified foods. In addition, biofortified crops are bred to contain other positive characteristics, such as drought resistance and high yields. The common bean, sweet potatoes, cassava, rice, wheat and maize are the main targeted crops of biofortification programs and initiatives. They aim to deliver iron, zinc and vitamin A to people in developing countries [6,7].

For programs that are already operational, measuring the coverage and consumption of industrially-fortified and biofortified foods is critical to assess program performance and estimate the amount micronutrients delivered. In addition, measuring the coverage and consumption of staple non-fortified and non-biofortified (aka conventional) foods is key to design programs and estimate their potential effectiveness. The Fortification Assessment Coverage Toolkit (FACT) was developed in 2013, and has been used in more than 16 countries to date to assess household coverage, consumption and nutrient contribution of industrially fortified foods [8,9].

As the scale of biofortification programs has steadily increased, there is now a need for a method to determine the coverage of biofortified foods. In this regard, GroundWork, Sagaci

Research, the University of Rwanda, and the Global Alliance for Improved Nutrition (GAIN), in collaboration with HarvestPlus and the International Potato Center (CIP), developed methods and tools for assessing the coverage of biofortified foods by building on and adapting the established FACT methods. The tools and methods were tested in Rwanda's Musanze District. The development of these tools and experience implementing this study will provide a critical foundation for researchers seeking to assess the coverage and consumption of biofortified foods using household surveys.

Rwanda was selected as the location for this study because there were two biofortified foods already available on the market; beans and orang fleshed sweet potato (OSFP). Moreover, beans do have an invisible iron trait, while OFSP have visible carotene traits, making it an ideal location to test these newly developed tools. In addition, Rwandans consume crops that could potentially be biofortified (cassava, maize) that are accessible to consumers.

In 2010, Rwanda was the first country to approve the official release of the first varieties of iron-biofortified beans, and in 2016 it was estimated by HarvestPlus that almost a million Rwandan farm households were growing and consuming biofortified beans [10]. The Scaling up Sweetpotato through Agriculture and Nutrition project (SUSTAIN) in Rwanda was a five-year project (2013-2018) aiming at increasing the adoption and consumption of orange fleshed sweet potatoes. The project has been designed together with the Rwanda Agriculture Board (RAB) to integrate its nutrition messages and support activities with the Ministry of Health's programs to reduce malnutrition through a combination of crop diversification and supplementation programs [11].

1.1 Rationale for developing and testing methods and tools

HarvestPlus has developed tools and methods to assess the proportion of people in farm households that grow biofortified crops and the proportion of people in farm households that consume biofortified foods. These methods, however, were tailored for farming households, and are not generally appropriate for non-farm households. As the scale of biofortification programs has increased globally, and as biofortified foods are now being consumed by non-farm households in many countries, there is a need to develop methods and tools for assessing the coverage and consumption of biofortified foods among the general population.

Moreover, since industrial fortification and biofortification program often occur concurrently, there is a clear opportunity to assess the coverage of biofortified foods as part of existing tools (e.g. FACT) that measure the coverage of industrially-fortified foods. In addition to individually assessing the coverage of these programs, methods to estimate the contributions of various foods to the nutrient intake of individuals is needed. This also builds on previously established methods in FACT.

As existing biofortification programs steadily grow and new investments in biofortification programs are continually being made by international and national stakeholders, there is an increased need to routinely measure the coverage of biofortification programs to provide

data to monitor program performance and identify programmatic challenges and bottlenecks.

1.2 Primary objectives

The overall goal of this study was to develop and test methods for assessing the coverage, consumption of biofortified foods, and their contribution to nutrient intakes of women of reproductive age (15 to 49 years) and children (6-59 months of age) in rural and peri-urban areas in Rwanda's Musanze District.

The specific objectives of the study were:

1. To develop biofortification coverage indicators and data collection tools to facilitate their measurement;
2. To assess the coverage of biofortified beans and sweet potatoes, and other potential foods for biofortification such as maize and cassava among households;
3. To assess storage and processing practices of biofortified foods and potential foods for biofortification among households;
4. To estimate the consumption of biofortified foods and potential foods for biofortification at the household-level and among children (6-59 months) and women (15-49 years);
5. To estimate the contribution of conventional and biofortified beans and OFSP to the intake of iron and vitamin A, respectively, among children (6-59 months) and women (15-49 years).

2 METHODS

2.1 Indicator and questionnaire development

2.1.1 Pre-survey activities

The survey was preceded by market visits and focus group discussions (FGDs) in order to appropriately design the questionnaire. In total, 10 different food markets in Musanze were visited with the aim of interviewing at least 10 vendors per market. The objective for market visits was to check who was selling biofortified foods and to see if sellers of certain crops (e.g. sweet potatoes, beans, etc.) were aware of biofortified foods and knew differentiating information about them, particularly related to their nutritional value. These visits helped our team in refining the tools and test the wording of specific questions for the household questionnaire. The market visit questionnaire can be found in Appendix 8.5.

The ten food markets were the Musanze food market, Byangabo market, Kagano market, Ndabanyurahe market, Cyabagarura market, Kinigi market, Bisate market, Karwasa market, Kinkware market, Nyiragihima market. Interviewers were instructed to recruit all vendors of beans and/or sweet potatoes in the 10 markets. In total, 114 vendors were interviewed out of the 116 eligible vendors identified. The main results of the market visit interviews are presented in Table 1 and Table 2. The results of market visits were used to inform the design of household questionnaire.

Most vendors sold either beans or sweet potatoes, only one vendor sold both crops. For beans, local measures (e.g. filled cans) were rarely used. Vendors used kilograms, bags, or other units (including baskets, boxes) as the main unit for selling sweet potatoes. Of the vendors selling beans and sweet potatoes about half of them procured the crops directly from a farmer.

Most of the bean vendors sold more than one bean variety and about half of the bean vendors sold high iron beans. The main reason given for not selling high iron beans was that they were not easily available. Surprisingly, nine out of ten vendors who sold high iron beans claimed that they could distinguish between high iron and normal iron beans by physical characteristic and almost the same proportion thought that the clients can recognize high iron beans by outward appearance. When asked how the clients can recognize high iron beans, 50% of the vendors answered “by the color”. Also, the majority of those vendors selling high iron beans promoted high iron beans and informed the customers about their advantages.

All vendors selling sweet potatoes sold fresh roots, only 4 also sold dried chips and none sold sweet potato flour. Only about 20% of sweet potato vendors sold OFSP. Similar to high iron beans, the main reason for not selling OFSP was the poor availability. Surprisingly, out of the 11 vendors selling OFSP only one had them available at the time of the visit. All other vendors reported that OFSP were not available at the time of the visit. Similar to high iron beans the

majority of those vendors selling OFSP promoted OFSP and informed the customers about their advantages.

Table 1. Results of vendor interviews (n=114) on biofortified beans in 10 markets in Musanze

Variable	N	% [a]	(95% CI) [b]
Proportion of vendors selling beans	114	53.5	(44.1; 62.5)
Proportion of bean vendors selling different bean varieties	61	83.6	(71.7; 91.1)
Proportion of bean vendors selling high iron beans			
Only high iron beans	61	1.6	(0.2; 11.2)
Both, high iron and normal beans	61	42.6	(30.6; 55.6)
How do vendors know that beans are high iron beans			
Certification	27	14.8	(5.3; 35.1)
Information from the person beans were bought	27	44.4	(26.2; 64.3)
Physical characteristic (shape, color, size)	27	88.9	(68.9; 96.7)
Main reasons for not selling high iron beans			
Never heard of high iron beans	34	17.7	(7.8; 35.2)
Not easily available	34	79.4	(61.6; 90.3)
They don´t sell well/ no demand	34	20.6	(9.7; 38.4)
Too expensive	34	11.8	(4.3; 28.6)
Units in which beans are sold			
Grams	61	6.6	(2.4; 16.6)
Kilograms	61	93.4	(83.4; 97.6)
Bags	61	3.3	(0.8; 12.6)
Can	61	1.6	(0.2; 11.3)
Main advantages of high iron beans			
High in iron	61	62.3	(49.2; 73.8)
Good for health	61	57.4	(44.4; 69.4)
Better quality	61	14.8	(7.7; 26.4)
Better taste	61	19.7	(11.3; 31.9)
Higher yield	61	18.0	(10.1; 30.1)
Proportion of vendors informing clients about advantages of high iron beans	27	55.6	(35.7; 73.8)
Proportion of vendors promoting high iron beans	27	63.0	(42.4; 79.7)
Proportion of vendors who think that the client can distinguish between high and normal iron beans by outward appearance	27	81.5	(60.9; 92.5)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 2. Results of vendor interviews (n=114) on orange fleshed sweet potatoes in 10 markets in Musanze

Variable	N	% [a]	(95% CI)[b]
Proportion of vendors selling sweet potatoes	114	47.4	(38.2; 56.7)
Proportion of SP vendors selling OFSP	54	20.4	(11.4; 33.6)
Main reasons for not selling OFSP			
Never heard of OFSP	43	11.6	(4.7; 25.8)
Not easily available	43	86.1	(71.5; 93.8)
Don´t like them	43	14.0	(6.2; 28.5)
They don´t sell well/ no demand	43	37.2	(23.7; 53.0)
No good yield	43	9.3	(3.4; 23.1)
Units in which sweet potatoes are sold			
Grams	54	3.7	(0.8; 9.9)
Kilograms	54	77.8	(64.3; 87.1)
Bags	54	14.8	(7.4; 27.4)
Other [c]	54	25.9	(15.7; 39.6)
Main advantages of OFSP			
Contain pro-vitamin A	54	40.8	(28.2; 54.6)
Good for health	54	53.7	(40.0; 66.8)
Better quality	54	7.4	(2.7; 18.6)
Better taste	54	16.7	(8.7; 29.5)
Proportion of OFSP vendors informing clients about advantages of OFSP	11	54.6	(22.6; 83.1)
Proportion of OFSP vendors promoting OFSP	11	63.6	(28.8; 88.3)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Other units include baskets, buckets, and boxes

Vendors were also asked for the names of high iron beans and OFSP in Kinyarwanda. Almost all vendors selling OFSP stated that there is a specific name in Kinyarwanda. The most frequent answers for OFSP were "Ibijumba bya carroti" (sweet potatoes which look like carrots) or simply "carotti". For beans, only 30% of the vendors selling high iron beans stated that there is a special term for those beans in Kinyarwanda. However, almost all of those vendors mentioned different terms, the term "fer" or "feri" was mentioned three times.

Two FGDs with adult women that are responsible for the food purchases for their households were conducted. The focus groups were conducted in one rural and one peri-urban location. These FGDs took place a few weeks before the household survey and were used to test some of the assumptions taken as well as to refine the tools. Specifically, one aim was to explore ways how to distinguish between biofortified and conventional varieties, if the varieties have no visible differences (biofortified / conventional beans).

The FGDs showed that most women were aware of crops which are high in minerals and vitamins; specifically, all of the women mentioned high iron beans and OFSP. They were not familiar with the term “biofortification” and all women stated that there is no word in Kinyarwanda or Swahili for “biofortification”.

Most of the FGD results were in conformity with the findings from the market visits. The most common terms for OFSP were “Ibijumba bya karoti” (sweet potatoes which look like carrots) or “carotti” or “Ibijumba orange” (orange sweet potatoes). Most women liked buying OFSP, but reported that OFSP had unfortunately disappeared from the market and were rarely available at the time of the FGDs (July 2019). OFSP were perceived as a healthy food, some of the women even perceived them as medicine. Women liked their cooking characteristics and the taste. In contrast to the vendors, it was stated that the OSFP were more expensive than white or yellow sweet potato varieties. In order to distinguish between OFSP and other sweet potato varieties, the women stated that it is best to cut them in order to see the orange flesh. However, some women stated that they can recognize OSFP by the leaves (small in size) and the size of the potato. The women mentioned that the main way of preparing OFSP is boiling and that OFSP are normally consumed with beans or other vegetables. Other ways of preparation included frying and roasting.

In Kinyarwanda there are many names for beans high in iron. Similar to the vendors, the women in focus groups mentioned among others the terms “Ibishyimbo bya Feri” (mineral beans) or simply “ferri”. Also, they stated that the high iron beans are more expensive than the conventional varieties. Women claimed that they can distinguish between biofortified and conventional by the color and also by the shape and size. However, they stated that the biofortified beans are white and pink and that biofortified beans are often sold as a mix of different beans. When shown pictures of biofortified and conventional varieties, the women were not able to clearly identify the biofortified beans.

Although the women in the focus groups and the vendors claimed that they can distinguish between biofortified and conventional bean varieties, the results indicate that identifying high iron beans poses a problem.

2.1.2 Questionnaire development

A household questionnaire was developed based on the FACT template questionnaire [9]. Questions and modules were adapted based on the scope of the biofortification program (i.e. number and type of *biofortifiable* and biofortified foods of interest) and additional questions related to biofortification were added (e.g. storage and home processing practices, knowledge, attitudes and practices, awareness and availability). Further, modules assessing the consumption of biofortified foods were modified to account for differences between biofortified foods and fortified foods. Specifically, the market visits showed that consumers purchased different crop varieties at the same time. For sweet potatoes for example vendors mixed OFSP and white/yellow sweet potatoes. Thus, we used a quantification technique in

the household questionnaire, the proportional piling method [12,13], which allowed us to assess the proportion of biofortified to biofortifiable crops.

One of the main obstacles in assessing the coverage of biofortified foods was the distinction between biofortified and biofortifiable crops without visible traits such as beans. Questions were added on how respondents think they can distinguish between biofortified and conventional varieties. Since the focus group discussion results showed that the majority of respondents falsely claim that they can identify biofortified beans, pictures of beans were taken as part of the questionnaire and a bean sample collected from every household to verify if beans were biofortified by an expert after completion of field work.

2.1.2.1 Impact pathway and coverage indicators

As a key objective of the study was to measure the coverage of selected biofortified foods, an evaluation was done to elucidate how biofortified foods can get to the household and be used. Figure 1 presents the flow of the program impact pathway (PIP). From left to right the program components relate to a smaller segment of the population. Awareness was greyed out since it does not necessarily fulfill the impact component cascade and is thus not a universally-applicable component. Specifically, it is possible that those people who are aware of the biofortified food can exceed those who consume the food vehicle. However, biofortified food consumption often depends on awareness creation since oftentimes biofortified foods differ from their conventional counterparts, either via organoleptic properties or in terms of price, thus people have to be aware of the benefits in order to purchase higher-costs biofortified foods. In order to overcome the problem of cascading, awareness could only be acquired of those persons who consume the *biofortifiable* food vehicle as only those are potential consumers.

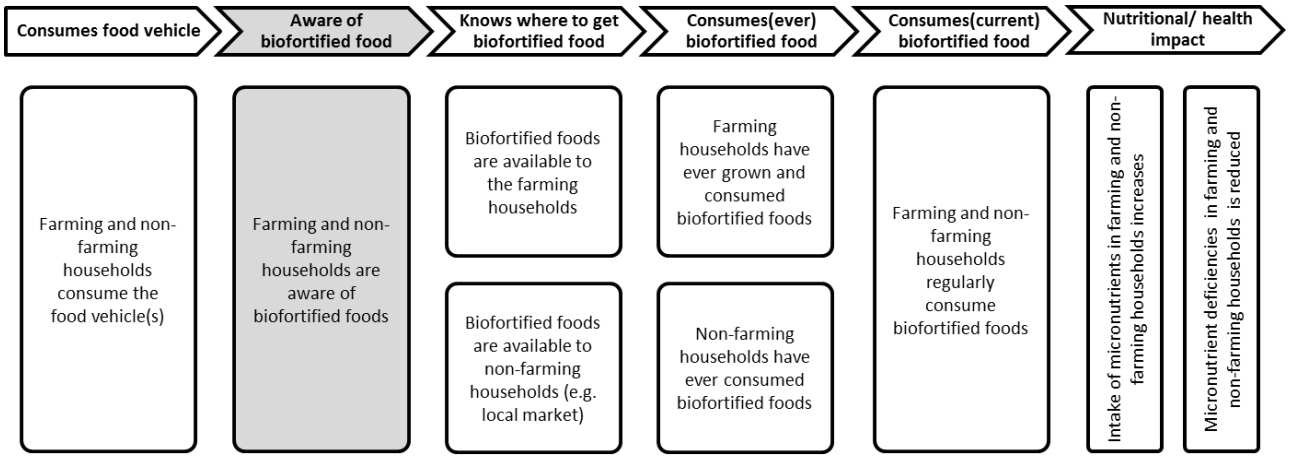


Figure 1 Program impact pathway for biofortified foods

A set of coverage indicators were developed based on the model developed by Tanahashi [14]. The Tanahashi framework has previously been adapted and used to assess coverage of large-scale food fortification programs as well as for infant and young child fortified food programs [15]. Building on this, the framework has been further modified to suit the assessment of coverage of biofortified foods. Figure 2 below displays a version of the Tanahashi model that has been modified to suite a biofortification context and identifies the various stages of coverage which have to be met before the goal of service achievement can be reached. In the biofortification context, the "goal of service achievement" would likely represent a programmatic target of current consumption of the biofortified food. While this target could conceivably be matched to the coverage of the food vehicle (i.e. the same proportion as indicator 1), it may, out of practicality, be lower due to programmatic factors, such as number and location of seed breeders, market demand for conventional foods, etc.

Indicator 1: Consumption of the food vehicle (i.e. proportion of households that consume a food vehicle in any form) shows if household consumes the crop, either conventional or biofortified in any form (i.e. boiled, fried, dried). This indicator is derived by tabulating the results from the question "*Does your household consume [insert crop here] at home?*"

Indicator / effect modifier 2: Awareness of the biofortified food shows if the respondent has ever heard of the biofortified food – (proportion of households that are aware of ……). This indicator is derived by tabulating the results from the question *"Have you ever heard of [insert biofortified food here]"?*

Indicator 3: Availability of the biofortified food describes if households have access, or knowledge of where to purchase/ obtain the biofortified food - (proportion of households that have access to, or knowledge of where to get, the biofortified food). This indicator is derived by tabulating the results from the question *"Do you know where to buy/ obtain [insert biofortified food here]?"*. This question is asked of farming households that produce the food themselves and might therefore rather buy seeds and non-households that procure the food exclusively for consumption, or households that obtain the crop from another channel (e.g. food aid, gift).

Indicator 4: Consumption of the biofortified food (ever) describes the proportion of households that have ever consumed the biofortified foods. This indicator is derived by tabulating the results from the question *"Have you ever bought/ grown/ received [insert biofortified crop here] for eating"?*

Indicator 5: Consumption of the biofortified food vehicle (currently) is a measurement that captures if households consume the biofortified food in any form (i.e. boiled, fried, dried). It is an *objective* indicator as it is *ideally* calculated either by a) having the interviewer visually confirm that the biofortified food with visible traits, or b) by collecting samples of foods with non-visible traits and having an expert determine if the food is/is not biofortified. To illustrate for biofortified foods with visible traits (e.g. orange color), the indicator is derived by first

asking the household respondent the question: *"The last time your household got [insert biofortified food here] for eating, what kind did you get?"*. If a biofortified food is mentioned, the interviewer would ask if there are any foods remaining from the last purchase, and if so, would observe the food and record if biofortified foods are present. If no food sample is available, classification will be solely based on the response to the question "*The last time your household got [insert biofortified food] for eating, what kind did you get?"* after showing the respondent pictures of conventional and biofortified foods (e.g. white/ yellow sweet potatoes and OFSP). For biofortified foods with non-visible traits (e.g. biofortified beans), a sample of the food will be collected if available in the household and later identified by a breeding specialist. Households that do not provide a bean sample will have to be excluded from the analyses for this indicator since the survey results show that respondents are unable to correctly identify biofortified varieties with non-visible traits.

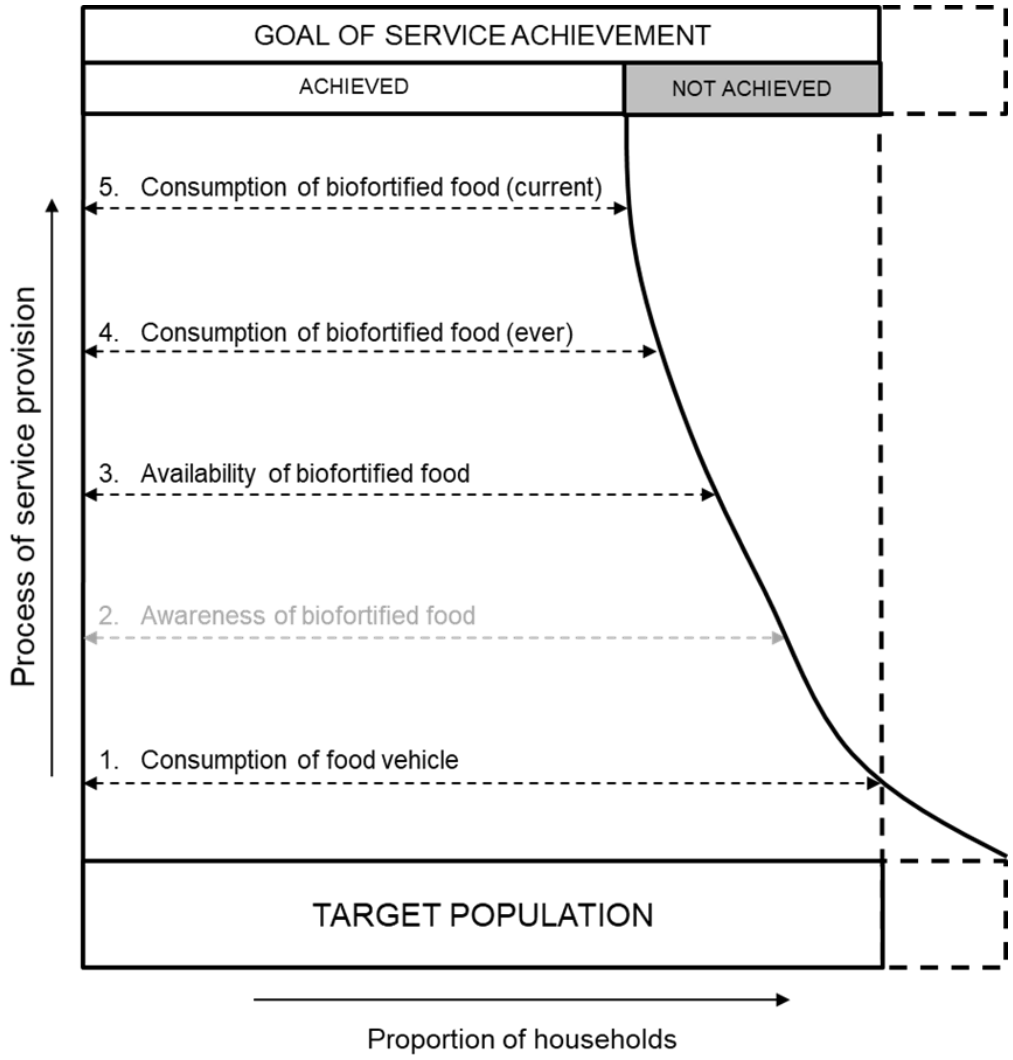


Figure 2. Tanahashi model adapted to biofortification context

2.2 Survey design, data collection and analysis

2.2.1 Survey design

A cross-sectional household study was undertaken. The target population was households, but a detailed households roster was conducted so that individual-level indicators for children (6-59 months) and women of reproductive age (15 to 49 years) could be calculated. As the objective of the study was methods development, the study was not designed to be representative at any level.

2.2.2 Study setting and key biofortified crops

The study was undertaken in two settings, peri-urban and rural areas in the Musanze District in Northern Rwanda. These areas were chosen to ensure that the tools developed are applicable to different settings.

The key biofortified crops grown in Rwanda are high-iron beans and orange fleshed sweet potatoes. The Musanze District was chosen to allow for testing the methods in a location with both a biofortified food with visible traits (orange fleshed sweet potatoes) and non-visible traits (high iron beans). According to the World Food Program, 90% of households grew beans (biofortified and conventional) in 2012 [13]. While beans were grown all over the country, the highest planting rates were in Central Rwanda. Sweet potatoes (any type) were reported to be grown by 40%-45% of households, and the highest planting rate could be found in districts in southern and northern Rwanda [16,17].

2.2.3 Timing and duration of study

As consumption of biofortified foods can be substantially influenced by seasonality, the study took place in August when most crops were available. In Rwanda, most of the sowing and growing takes place in October, November, and December. Depending on the crop, harvest is normally from December to July. Thus, in August most of the crops were expected to be available.

Field work training started on the 21st of August 2019 and the actual field work on the 24th of August 2019. In total data collection took 8 days and was completed on the 31st of August 2019.

2.2.4 Sampling approach and sample size determination

The study aimed at including 250 randomly selected households located in 25 clusters (or primary sampling units, PSUs) in Musanze District (see Figure 3 & Appendix 8.1). Calculating a specific minimum sample size was difficult because there were no prior assessments of the coverage of biofortified foods in Rwanda, and thus no data that be used to estimate parameters of heterogeneity and coverage.

To calculate the sample size, we assumed an intra-cluster correlation coefficient (ICC) of 0.1, which is based on design effects encountered in FACT surveys. Potentially, the ICC for biofortified foods could be somewhat higher because regular fortified foods are, almost by definition, centrally processed and widely marketed, whereas biofortified foods could be grown by the family for their own use or grown by small producers and marketed only locally. Hence, there may be greater difference among clusters in the coverage of biofortified foods than for conventionally fortified foods.

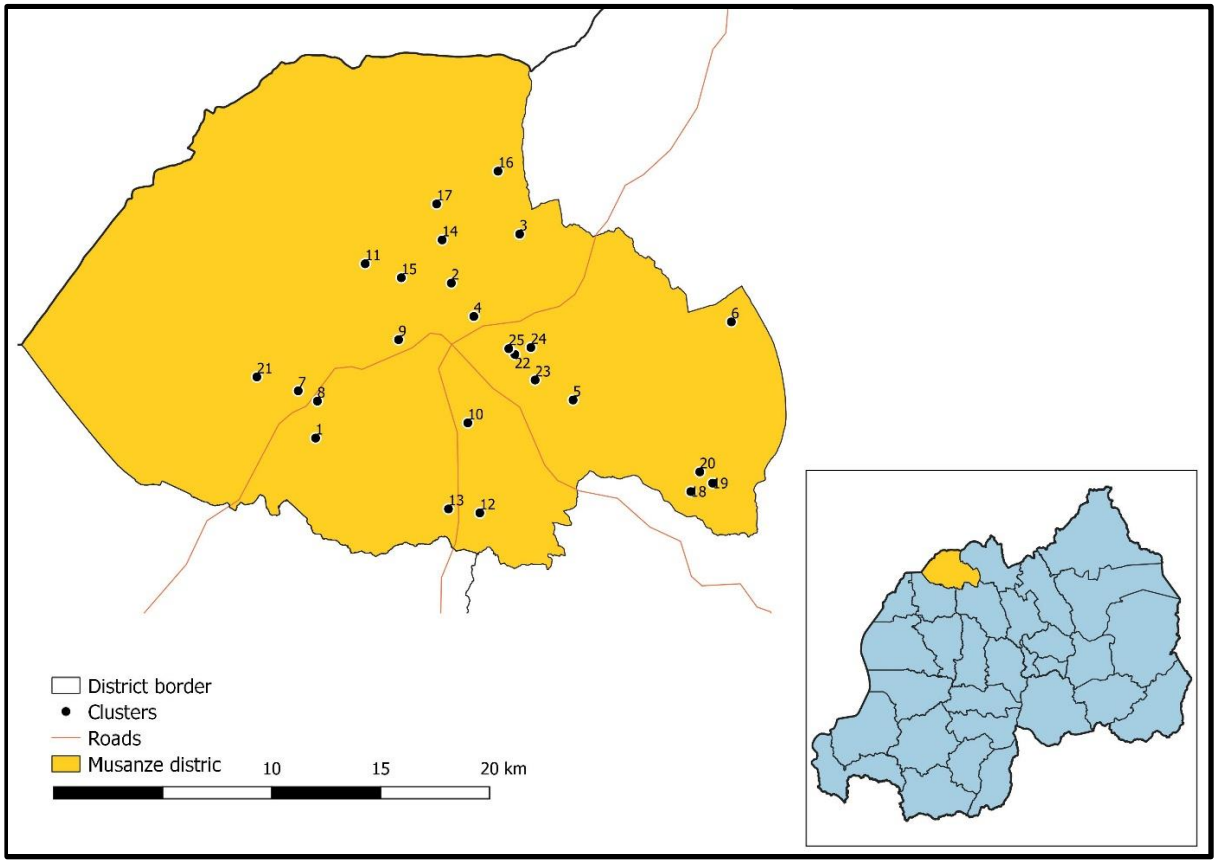


Figure 3. Location of 25 clusters included in household coverage survey, Musanze District, Rwanda

In addition, we have assumed that transport may be difficult among selected primary sampling units; therefore, precision calculations are based on having 25 clusters in the entire study. We have also used a coverage estimate of 25% in precision calculations.

As can be seen in the Figure 4, the precision does not increase greatly with sample sizes greater than 200 households given the assumptions described above. Therefore, this study aims at collecting data from 200 households selected in 25 clusters. To account for non-response and missing households, the study selected 10 households in each primary sampling unit in order to gather data on at least eight households.

Villages were used as PSUs (clusters) as they were the smallest unit with population in Rwanda. In the first stage of sampling, simple random sampling was used as no information

about the number of households or individuals in each PSU could be obtained for all villages in Musanze. Subsequently, the selected villages were visited, and population lists from each PSU were obtained from village leaders. For 19 and 6 PSUs, household lists and information on the total population of the PSU were obtained, respectively. Using the household list information, and assuming that average household size did not vary by village, the number of households was selected based upon proportion of the total population accounted for by each PSU. For the 6 PSUs with information on the total population, households were randomly selected using EPI cluster survey methodology [18]. The EPI methodology was modified to increase its robustness and instead of selecting households starting from one central point in the PSU, two central points, at least 200 meters apart were identified and household selection conducted.

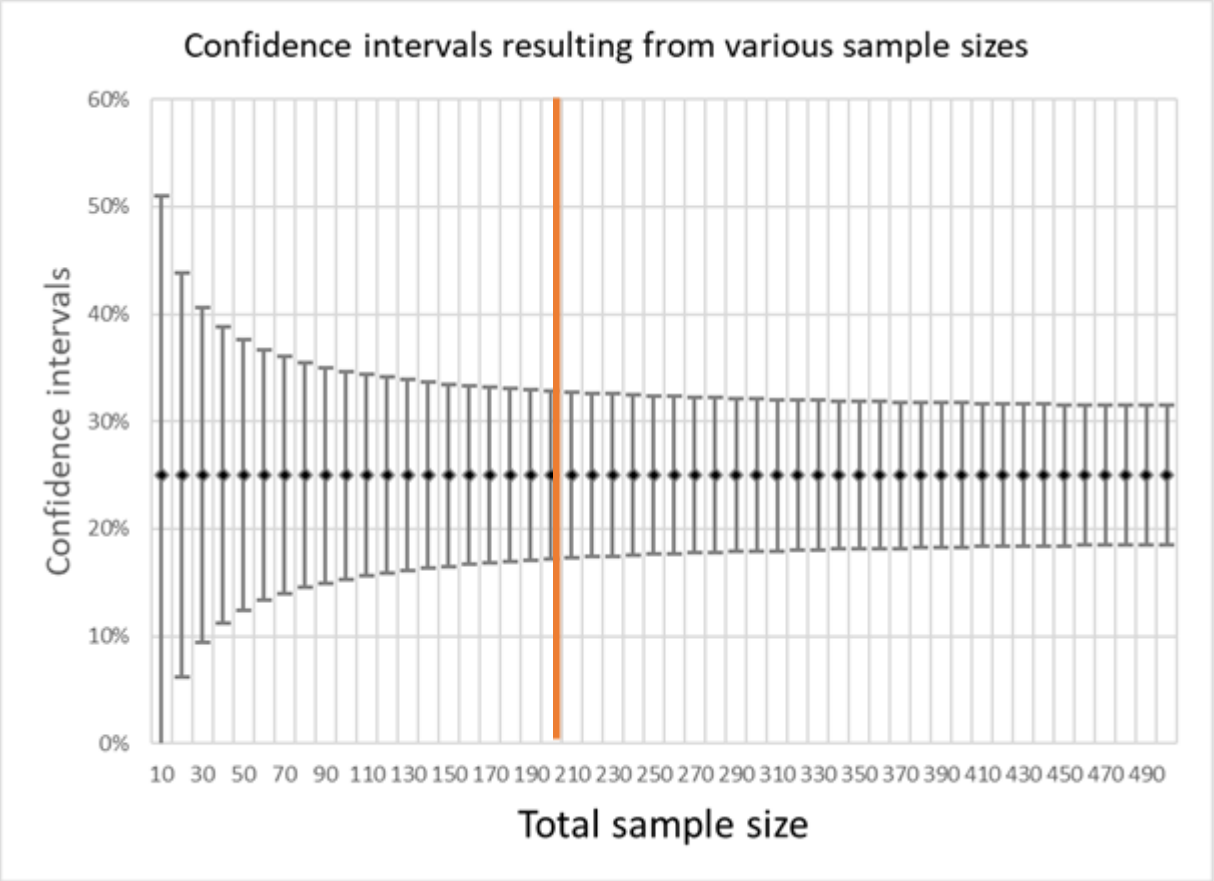


Figure 4. Confidence intervals obtained when utilizing differing sample sizes

2.2.5 Data collection

Data collection was conducted using tablet computers with the open data kit[1] (ODK) software installed. A mobile questionnaire with associated variable information, including skip patterns was developed. The questionnaire was programmed in English and Kinyarwanda, so that it

[1] https://opendatakit.org/

was easier for the interviewer to administer the interview in the local language. During training, specific terms and phrases that were challenging to be translated from English to Kinyarwanda were discussed.

A household interview was conducted using a household questionnaire designed to collect information on coverage, consumption, storage, processing, knowledge, attitudes, practices, and awareness of the conventional food vehicles and the biofortified foods. Additional demographic and socioeconomic information were also collected. Trained enumerators administered the questionnaire to the person in the household most knowledgeable about food purchasing and preparation in the household (who was at least 18 years old). The interviewer read the instructions to the participant and then read each question along with all possible responses, where appropriate.

2.2.6 Field team composition

Field staffs were recruited from Musanze District, and candidates with previous experience collecting data were prioritized. Interviewers conducting the market visit interviews were also recruited for the actual coverage study.

In total, there were two field teams with an identical composition. Each field team consisted of 5 interviewers and one field coordinator. Each interviewer was equipped with a tablet computer (for electronic data collection) and other data collection forms. The field coordinator was in charge of initial sensitization of community leaders when first visiting a PSU and provided overall supervision and team coordination. Further the field coordinator was responsible for supervising the field work of his/her team and for troubleshooting any issues that arose.

Each team visited about 20 households and completed approximately 18-20 interviews per day. Field teams worked seven days a week. Each interviewer was responsible for interviewing 4-5 households per day.

To facilitate the work in selected PSUs, a local guide was recruited by the team in order to increase the trust of the local population in the teams.

2.2.7 Training and field testing

Training for study team members consisted of two days of classroom instruction and practice and one day of field testing of all study procedures. Interviewer training included discussion of each question, practice reading, role playing, and on how to use the interview device (tablet computer). As a part of their training, interviewers conducted a field test of the questionnaire. Based on feedback provided from the interviewers, minor modifications were made to the questionnaire in order to ensure their clarity and cultural appropriateness.

During the training and field work, trainers from GroundWork and Sagaci Research comprised the team of supervisors.

The initial supervision during the first few days of field work was very intense, and each team was accompanied by a supervisor to rule out remaining flaws in the procedures and approaches taken.

2.2.8 Ethical considerations

Ethical approval for the survey (No 367/CMHS IRB2019) was obtained from Ethical Review Board of the University of Rwanda; the approval letter is presented in Appendix 8.2.

For household interviews, written informed consent was sought from the respondent. If any consenting survey participants were unable to read and write, the consent form was read out loud to them and a witness signed on their behalf. The respondents were also told that they are free to withdraw from participation in the survey at any time, even after written consent had been given.

2.2.9 Data management and analysis

2.2.9.1 Data monitoring

Interview data was uploaded from the tablets to a platform on a daily basis. Data were monitored continuously and in case of systematic errors made by both teams, the team coordinators were immediately informed about the problem, so the problem was not repeated; sporadic errors were directly reported to the respective field coordinators.

2.2.9.2 Data analysis

Data analysis of market visits and household interviews was done using Stata/IC version 14.2. As villages were selected with equal probability using simple random sampling and as the number of households selected in each village was determined by the total number of households residing in the village, there was an equal probability of selecting each household from the sample frame. As such, no statistical weights were required to account for the different probability of selection. For continuous variables, means with standard deviations were calculated. For categorical variables, proportions were calculated to derive the prevalence of various outcomes. The statistical precisions of all prevalence estimates were assessed by using 95% confidence limits.

2.3 Indicator definitions

2.3.1 Coverage of biofortified foods and other potential foods for biofortification

As these household-level indicators were developed as part of the study, a detailed description of their development and definitions can be found in section 3.2 of the results. All the coverage indicators were estimated for the two biofortified foods of interest, i.e. beans and sweet potatoes. Additionally, the first indicator (consumption of the food) was estimated for other potential foods for biofortification, i.e. cassava, cassava flour, maize and maize flour.

2.3.2 Consumption of biofortified foods and other potential foods for biofortification

To determine the individual daily consumption of conventional and biofortified beans and sweet potatoes for children (6-59 months) and women (15-49 years) based on reported household purchases, the adult male equivalent (AME) method was used [19,20]. The AME is the proportion of an adult male's energy requirement that is needed by each age- and sex-specific group. First, the AME was assigned for each household member using data on age and sex based on data collected in the household roster component of the household questionnaire (see Appendix 8.7). Secondly, the AMEs for all household members were summed to determine the total AME in each household. Thirdly, the quantity of the food obtained by the household each day was calculated based on the reported quantities of the food vehicle purchased and the usual duration the food lasts in the household. Fourthly, individual consumption (in grams) of crops was estimated for women and children by dividing their respective individual AME by the total household AME, and multiplying the individual share of the total AME by the total household daily consumption of the crop.

As some respondents could have had difficulty estimating the quantities beans and sweet potatoes purchased or grown at home, the distributions of grams per day per AME in each household were examined to identify outlier households. Households — and the individuals residing therein — with improbably consumptions of beans and sweet potatoes were excluded from the individual-level analysis of consumption (i.e. grams/day), iron and vitamin A intake, and % RNI and %EAR obtained from each food.

For beans, an "improbably consumption threshold" was set at 500 grams per day per AME. Bean consumption in Rwanda is estimated to be almost 70kg *per capita* and year [21], which is equivalent to 192grams per day *per capita*. Since beans are the main staple food, we assumed that about 80% of the population are consumers. Assuming a normal distribution of consumption the mean ± 3SD daily bean intake of consumers is 240g ±239g, resulting in a maximum consumption of up to 500g/day. We therefore excluded children and women from households where the consumption per AME was greater than 500 grams / day.

For sweet potatoes, the "implausible consumption threshold" was established using food balance sheet data and estimates of the proportion of consuming households. According to FAO food balance sheet data, the average *per capita* consumption of sweet potatoes in 2018 was about 90 kilograms per year [22], which is equivalent to 247 grams per day *per capita*. We estimate that 56% of the population in Rwanda consumes sweet potatoes, as 45% of households have been reported growing sweet potatoes and 11% of non-farm households reported purchasing sweet potatoes [17]. Thus, average sweet potato intake of consumers is estimated to be 441 gram per day (247 ÷ 0.56). Assuming a normal distribution of consumption, three standard deviations from the mean would be 437 grams. As this would result in a maximum daily consumption near to 1000 grams, we excluded children and women from households where the consumption per AME was greater than 1000 grams / day, as we consider this level of consumption implausible.

For other potential biofortified foods (i.e. cassava, cassava flour, maize and maize flour), consumption was estimated at the household level in grams per day per AME based on reported quantities of the food vehicle purchased and the usual duration the food lasts in the household. Importantly, consumption estimates (i.e. grams per day per AME) do not take into account the fact that some foods are seasonal and are not available all 12 months of the year.

2.3.3 Estimating nutrient intake and contribution to the RNI and EAR from biofortified foods

Nutrient intake was calculated using the individual consumption in grams per day for each food vehicle (see Section 2.3.2) multiplied by the nutrient levels in the food. Subsequently, vitamin A concentrations were adjusted to account for losses due to various preparation methods. For iron, individuals were assigned an RNI of either 5%, 6%, or 8% bioavailability based on the method used for preparing and cooking beans. The RNI was set for each individual based on the bioavailability of iron in the beans as the survey did not contain other information (e.g. type and quantity of meat consumed, quantity of vitamin C consumed) that would be needed to establish a population-level RNI for iron.

For beans, the %RNI for iron was calculated by dividing the individual daily iron intake in milligrams by the RNI of iron. For OFSP, the %RNI or % EAR for vitamin A was then calculated by dividing the individual daily intake of retinol equivalents in micrograms by the RNI or EAR established for children and women. Importantly, the age-range for women for the RNI and EAR estimates given in WHO/FAO food fortification guidelines [2] is 19 to 50 years. In a small deviation, we have applied the WHO/FAO RNI and EAR estimates to women of reproductive age (i.e. women 15-49 years of age), as this group is frequently a target group for fortification and biofortification programs (see Table 3 and Table 4**Error! Reference source not found.**).

Table 3. Recommended nutrient intake (RNI) for target population groups and iron and pro-vitamin A [2]

RNI	0-3 years	4-6 years	NPW (19-50y)
Vitamin A (µg RE[a])	400	450	500
Pro-vitamin A (µg)[b]	4853	5400	6000
Iron (mg)			
5% bioavailability (mg)	11.6	12.6	58.8
6% bioavailability (mg)	10.4	11.3	52.9
7% bioavailability (mg)	9.3	10.1	47.0
8% bioavailability (mg)	8.1	8.8	41.2
9% bioavailability (mg)	7.0	7.6	35.3
10% bioavailability (mg)	5.8	6.3	29.4

[a] RE= retinol equivalent

[b] assuming 12:1 pro-vitamin A :retinol equivalency

Table 4. Recommended estimated average requirement (EAR) for target population groups (pro)-vitamin A

EAR	0-3 years	4-6 years	NPW (19-50y)
Vitamin A (µg RE[a])	286	321	357
Pro-vitamin A (µg)[b]	3,432	3,852	4,284

[a] RE= retinol equivalent

[b] assuming 12:1 pro-vitamin A : retinol equivalency

Various assumptions were made to estimate the contribution of biofortified and biofortifiable foods to the RNI and EAR of women and children:

- First, the iron concentration of beans and the pro-vitamin A concentration OFSP was estimated using existing literature;
- Second, different micronutrient retentions (pro-vitamin A) and bioavailabilities (iron) were used for different processing and storage methods;
- Third, household-level daily consumption of beans and sweet potatoes was estimated along with the amount of respective iron and vitamin A obtained from these foods;
- Forth, individual AMEs for women in children were calculated for each household, and based on their share of the total AMEs in their households, the food and nutrient intakes were calculated, followed by the individual-level RNIs and EARs for children and woman.

For conventional and biofortified beans, we used iron concentrations of 50ppm (i.e. 50mg iron per kilogram of beans) and 100ppm (100mg iron per kilogram of beans), respectively [21]. These concentrations were also used to calculate the iron intake from processed beans as iron losses during processing and storage are neglectable. The cooking method used has an impact on the concentration of iron inhibitors, such as phytic acid and polyphenols and thus on iron bioavailability. Therefore, questions regarding the soaking and cooking of beans were included in the questionnaire. Studies have shown that the largest reduction of iron-absorption inhibitors in beans occurred when beans were soaked in water prior to cooking but cooked without the soaking water, followed by beans cooked without soaking prior to cooking. Highest concentrations of iron-absorption inhibitors were detected in pre-soaked beans cooked with the soaking water [23–27]. Table 5 presents the assumptions regarding iron bioavailability drawn from bioavailability data from bean iron absorption studies [21]. As different processing methods were used in the same household, the proportional piling method was used to assess proportion of beans cooked using each method, and the bioavailability factors were applied accordingly.

Table 5. Iron bioavailability for different processing methods in beans

Soak beans prior to cooking	Preparation method	Iron bioavailability
No	Cooking without soaking	6%
Yes	Cooking with the soaking water	5%
Yes	Cooking without the soaking water	8%

For OFSP we used a concentration of 100ppm of pro-vitamin A [28] for the raw crop, but actual concentration of the processed crop differed depending on the storage and processing methods. The pro-vitamin A concentration in raw conventional sweet potatoes is about 2ppm.To calculate the proportion of RNI and EAR received from conventional sweet potatoes and OFSP, a 12:1 pro-vitamin A: retinol equivalency ratio was assumed. Regarding pro-vitamin A retention during processing and storage of OFSP, we found no information about the effect of storage time and conditions on the pro-vitamin A concentration in the fresh sweet potato root. However, drying fresh sweet potato roots to produce dried chips or flour as well as the storage time of the chips and flour reduces the concentration of pro-vitamin A. To calculate the pro-vitamin intake from sweet potato flour different retentions were applied for the different drying methods (Table 6) and storage times (Table 7). Like storage and drying, the various processing methods (boiling, frying, baking) have an impact on the pro-vitamin A concentration in OFSP. Therefore, different pro-vitamin A retentions were applied for the different processing methods (Table 8). For OFSP, the different processing methods have no effect on the bioavailability of pro-vitamin A.

Table 6. Pro-vitamin A retention for different drying methods [29]

Drying method	Retention (%)
Shade drying	95%
Oven drying	85%
Sun drying	80%

Table 7. Effect of storage time on pro-vitamin A retention in sweet potato flour or dried chips [29,30]

Storage time	Retention (%)
1 month	70%
2 months	50%
3 months	35%
4 months	25%
5 months	15%
6 months	10%
>6 months	0%

Table 8. Pro-vitamin A retention after different processing methods [29]

Processing method	Retention (%)
Boiling	85%
Roasting	85%
Steaming	73%
Frying	70%
Baking	69%

2.3.4 Calculation of wealth index and improved water and sanitation

A wealth index was calculated using the principal component analysis method commonly employed by UNICEF Multiple Indicators Cluster Surveys, the World Bank, and the World Food Programme [31,32]. Characteristics of the dwelling, water and sanitation facilities, and ownership of durable goods were included in the principal component analysis. A wealth index was calculated for each household and split into quintiles on unweighted data to permit the cross-tabulation of coverage and consumption indicators by household wealth.

3 RESULTS

3.1 Household characteristics

Detailed information on household demographics of participating households can be found in Section 7 (Supplemental Tables; Table 20-Table 24). In total, 242 household were included in the survey, 64.5% and 35.5% of households were located in rural and peri-urban areas, respectively. The household response rate was 96.8%. Most households had a male household head (72.3%), and on average, households had 4.3 members. About 85% of the households had at least one woman of reproductive age, and about 40% had at least one child aged 0-59 months.

Almost all households had access to a safe water source and consequently safe drinking water. Conversely, only about half of households had adequate sanitation facilities. Only one-quarter of surveyed households had a handwashing site in the house or plot, and of those, about 67% had water at the site and almost all had soap.

About 63% of the households owned agricultural land. Approximately 43% owned livestock, and the main livestock owned by these households was cattle (58.7%), chicken (27.9%), sheep (22.1%), pigs (20.2%) and goats (17.3%).

3.2 Household coverage of biofortified foods and potential foods for biofortification

Five coverage indicators were developed to assess the various levels in which specific biofortified foods are being marketed, distributed, and accessed. These coverage indicators provide multiple data points about the functionality of an existing biofortification program. Those coverage indicators assessed are: 1) the consumption of the food vehicle (biofortified or conventional); 2) the awareness of biofortified food vehicle; 3) the availability of biofortified food vehicle; 4) the consumption of the biofortified food vehicle (ever) and 5) the consumption of biofortified food vehicle (current).

3.2.1 Beans

Figure 5 illustrates the operation curve for the five coverage indicators for beans. Nearly all households (99.2%; n=240) surveyed consume beans (indicator 1). The proportion of households that had previously heard of biofortified beans (indicator / effect modifier 2) was approximately 65%, showing that approximately one-third of bean consumers were unaware of biofortified varieties. The “availability coverage” — or coverage of households that knew where to purchase or obtain biofortified beans — was less than 30% (indicator 3). Only about 15% of the households had ever bought / grown / received biofortified beans (indicator 4), which was only about 60% of those who knew where to buy biofortified beans. The current coverage of biofortified beans was 10% (indicator 5), which was calculated using households that provided a bean sample (n=202) whose variety could be identified. Of these households, 2.5% were consuming beans that were completely biofortified, and 7.9% were consuming beans that were a mixture of biofortified and conventional beans.

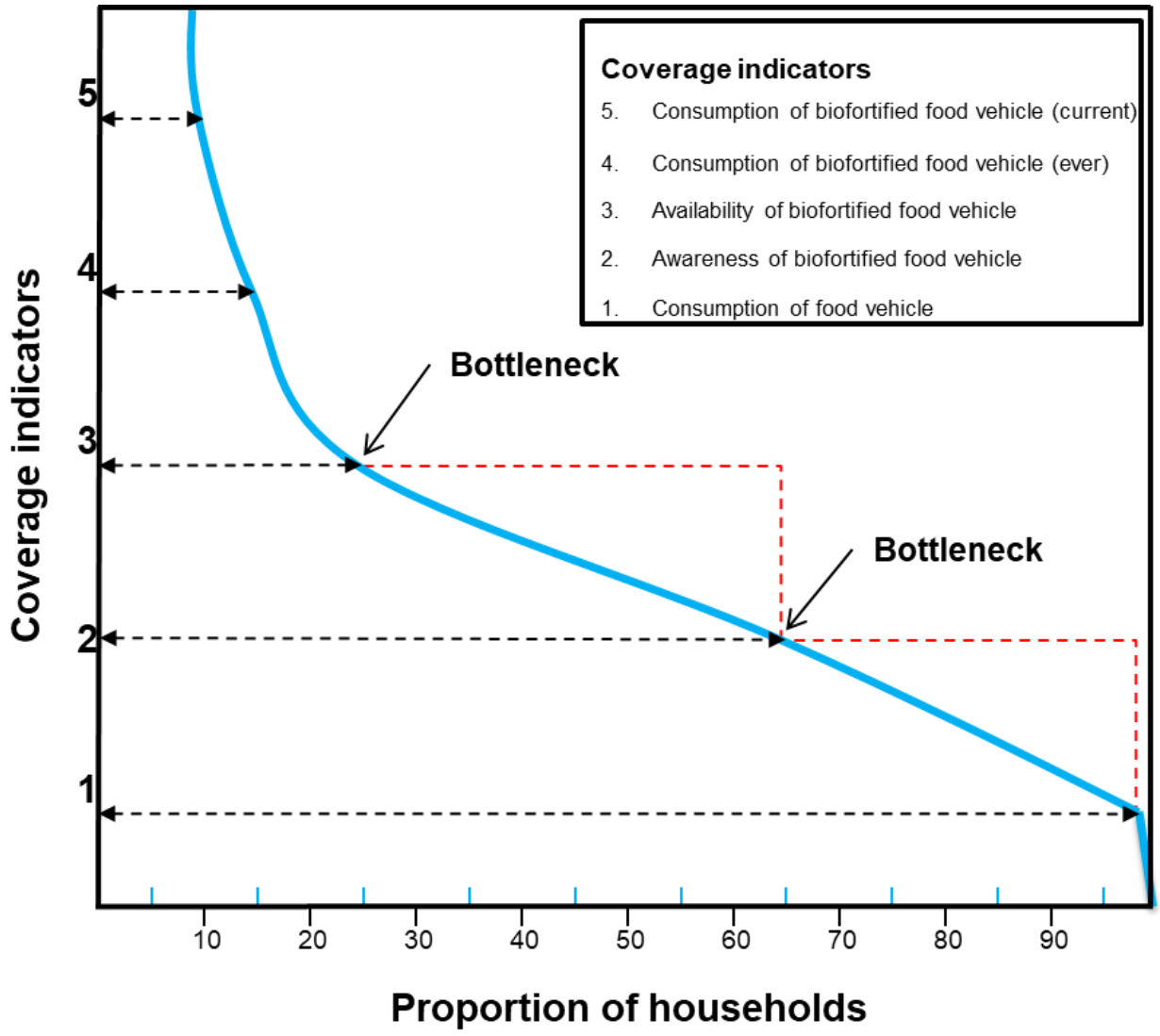


Figure 5. Coverage indicators for biofortified beans by proportion of surveyed households

Almost all surveyed households consumed beans, and no significant associations were found between bean consumption by rural and peri-urban residence, sex of the household head, household land ownership, or household wealth quintile. Also, no differences were found between households that grew beans at home and households that bought the beans the last time they got beans (Table 9 & Table 11).

Overall, about two-thirds of the households had ever heard of biofortified beans. Neither rural or peri-urban residence, sex of household head, household land ownership, nor household wealth quintile was associated with bean awareness. Also, no significant differences in awareness of biofortified beans were found between households which grew bean at home and those that bought the beans the last time they got beans. Most of the households stated that they heard of biofortified beans during village or community meetings or from family / friends / neighbors (Table 9, Table 12, & Table 25).

Overall, 23.6% of households knew where to buy biofortified beans; 20.5% rural and 29.1% peri-urban households, a difference which was not significant (Table 12). Most of the households stated that beans were available in the market or street stand (75.4%; Table 25). Neither sex of household head, household land ownership, and household wealth nor if household home grew or bought the beans were associated with biofortified bean availability (Table 9 & Table 13).

Similarly, the survey found no significant differences related to indicator 4 (consumption of the biofortified bean (ever)) for any of the investigated variables (Table 9 & Table 14). Of note, most households had positive impressions of biofortified beans, and only a small number of households cited negative characteristics. When asked what they like about biofortified beans, most households stated “taste” (56.0%) and “are good for health” (42.1%; Table 25).

Overall, only 10% of households consumed biofortified beans the last time they purchased or acquired beans. There were no statistically significant differences in the coverage of biofortified beans by residence, sex of the household head, household land ownership, nor wealth quintile. There was also no difference in the coverage if the households purchased beans or grew beans themselves (Table 9 & Table 15).

Table 9. Household coverage of biofortified beans in rural and peri-urban households

Indicator	Total			Peri urban			Rural			p-value
	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	
Household consumes beans										
Yes	240	99.2	(96.7, 99.8)	84	97.7	(91.1, 99.4)	156	100.0		0.057
No	2	0.8	(0.2, 3.3)	2	2.3	(0.6, 8.9)	0	-		
Household is aware of biofortified beans [c]										
Yes	159	65.7	(59.5, 71.5)	60	69.8	(59.2, 78.6)	99	63.5	(55.6, 70.7)	0.978
No	83	34.3	(28.5, 40.5)	26	30.2	(21.4, 40.8)	57	36.5	(29.3, 44.4)	
Where respondent heard of biofortified beans? [d]										
Village/ community meetings	55	34.6	(27.5, 42.4)	14	23.3	(14.3, 35.8)	41	41.4	(32.1, 51.4)	0.002
Relatives/ friends/ neighbors	45	28.3	(21.8, 35.9)	20	33.3	(22.5, 46.2)	25	25.3	(17.6, 34.8)	0.276
Health extension workers	10	6.3	(3.4, 11.4)	3	5.0	(1.6, 14.5)	7	7.1	(3.4, 14.2)	0.604
Community leaders	13	8.2	(4.8, 13.6)	2	3.3	(0.8, 12.5)	11	11.1	(6.2, 19.1)	0.086
Market place/ shop	11	6.9	(3.8, 12.1)	6	10.0	(4.5, 20.7)	5	5.1	(2.1, 11.7)	0.237
Biofortified beans are available to household [e]										
Yes	57	23.6	(18.6, 29.4)	25	29.1	(20.4, 39.6)	32	20.5	(14.9, 27.6)	0.135
No	185	76.4	(70.6, 81.4)	61	70.9	(60.4, 79.6)	124	79.5	(72.4, 85.1)	
Where? [f]										
Shop	14	24.6	(14.9, 37.7)	5	20.0	(8.3, 40.7)	9	28.1	(15.0, 46.4)	0.486
Farmer	17	29.8	(19.1, 43.3)	6	24.0	(10.9, 44.9)	11	34.4	(19.8, 52.6)	0.403
Market/street stand	43	75.4	(62.3, 85.1)	18	72.0	(51.1, 86.4)	25	78.1	(60.1, 89.4)	0.599
Moving street vendor	2	3.5	(0.8, 13.5)	1	4.0	(0.5, 24.7)	1	3.1	(0.4, 20.1)	0.861
Household ever consumed biofortified beans [g]										
Yes	37	15.3	(11.3, 20.4)	14	16.3	(9.8, 25.7)	23	14.7	(10.0, 21.3)	0.752
No	205	84.7	(79.6, 88.7)	72	83.7	(74.3, 90.2)	133	85.3	(78.7, 90.0)	

Table cont. on next page

Indicator	Total			Peri urban			Rural			p-value
	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	
Household currently consumes biofortified beans [h]										
Yes	21	10.4	(6.9, 15.5)	7	10.9	(5.3, 21.3)	14	10.1	(6.1, 16.5)	0.864
No	181	89.6	(84.5, 93.1)	57	89.1	(78.7, 94.7)	124	89.9	(83.5, 93.9)	

Note: The n's are un-weighted denominators for each subgroup; subgroups that do not sum to the total have missing data.

[a] Percentages are unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Households that reported not being aware of IB and households that reported not consuming beans were classified as 'No'.

[d] Includes only households that were aware of IB; respondents were able to provide multiple responses

[e] Households that did not know where to buy/obtain IB and households that reported not consuming beans were classified as 'No'

[f] Includes only households that knew where to buy/obtain IB; respondents were able to provide multiple responses

[g] Households that did not consume beans and households that never consumed IB were classified as 'No'

[h] Households that did not consume beans and household that did not consume IB at the time of the survey were classified as 'No'

Although the outward appearance (color, shape, size) of biofortified bean varieties differs from conventional bean varieties, it is often difficult for consumers to distinguish between biofortified and conventional varieties. The differences in the appearance of biofortified conventional beans are minor, and thus, in addition to asking the respondent if they got biofortified beans at the last purchase, a bean sample was collected. Those samples were examined by a bean expert from HarvestPlus to determine which of the samples actually contained biofortified beans. Results of the household bean identification analysis are shown in Figure 6. Overall, about 80% of households correctly identified the kind of bean they ate (biofortified or conventional). However, of those households that presumed they were eating biofortified beans (7.9%), two-thirds were mistaken (5.4%). Approximately the same proportion of households falsely claimed eating conventional beans (6.4%). A small proportion of households reported that they did not know of biofortification status of the beans they consumed, and 1.5% and 5.4% consumed biofortified and conventional beans, respectively.

Bean identification results were similar between households that purchased beans and those that grew the beans themselves, and most households that claimed to be consuming biofortified beans were incorrect. Among households that purchased beans, five households reported consuming biofortified beans, but only two of these households were correct. Among households that grew their own beans, 11 households claimed to be consuming biofortified beans, but only three were correct.

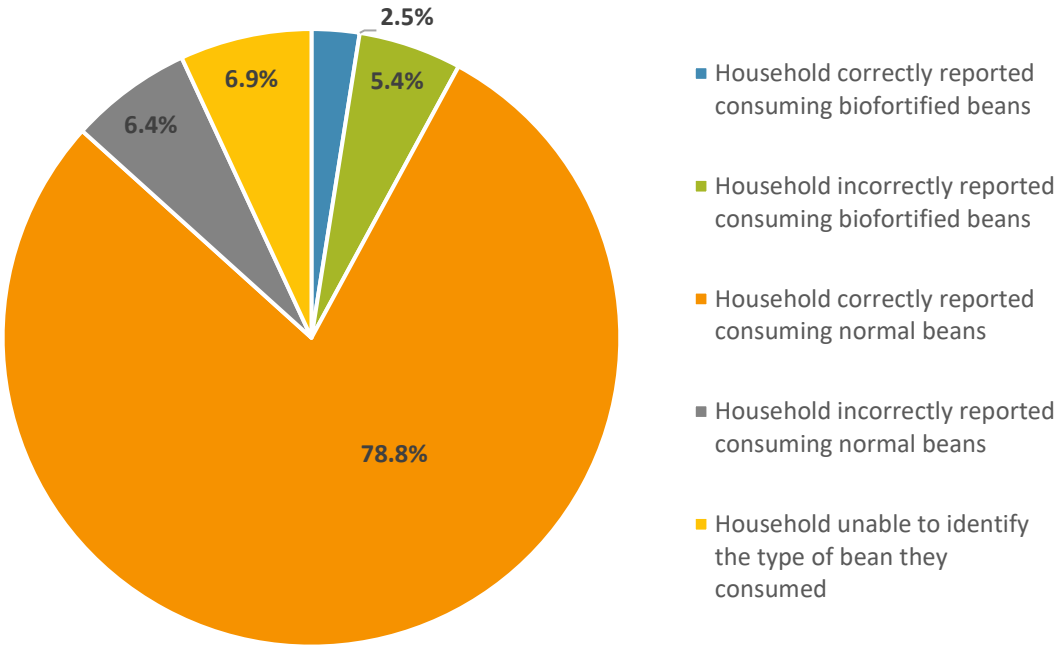


Figure 6. Correct and incorrect identification of biofortified beans by the households

3.2.2 Sweet potatoes

Figure 7 illustrates the operation curve for the five coverage indicators for sweet potatoes. While consumption of sweet potatoes is more than 96% (indicator 1), the proportion of households that had previously heard of OFSP (indicator / effect modifier 2) was only approximately 50%. Only about 11% of households reported that OFSP were available and knew where to buy OFSP (indicator 3). Almost an identical proportion of households had also had ever bought OFSP (indicator 4). The current household coverage of OFSP was very low; only about 2% of households bought OFSP the last time they bought sweet potatoes (indicator 5).

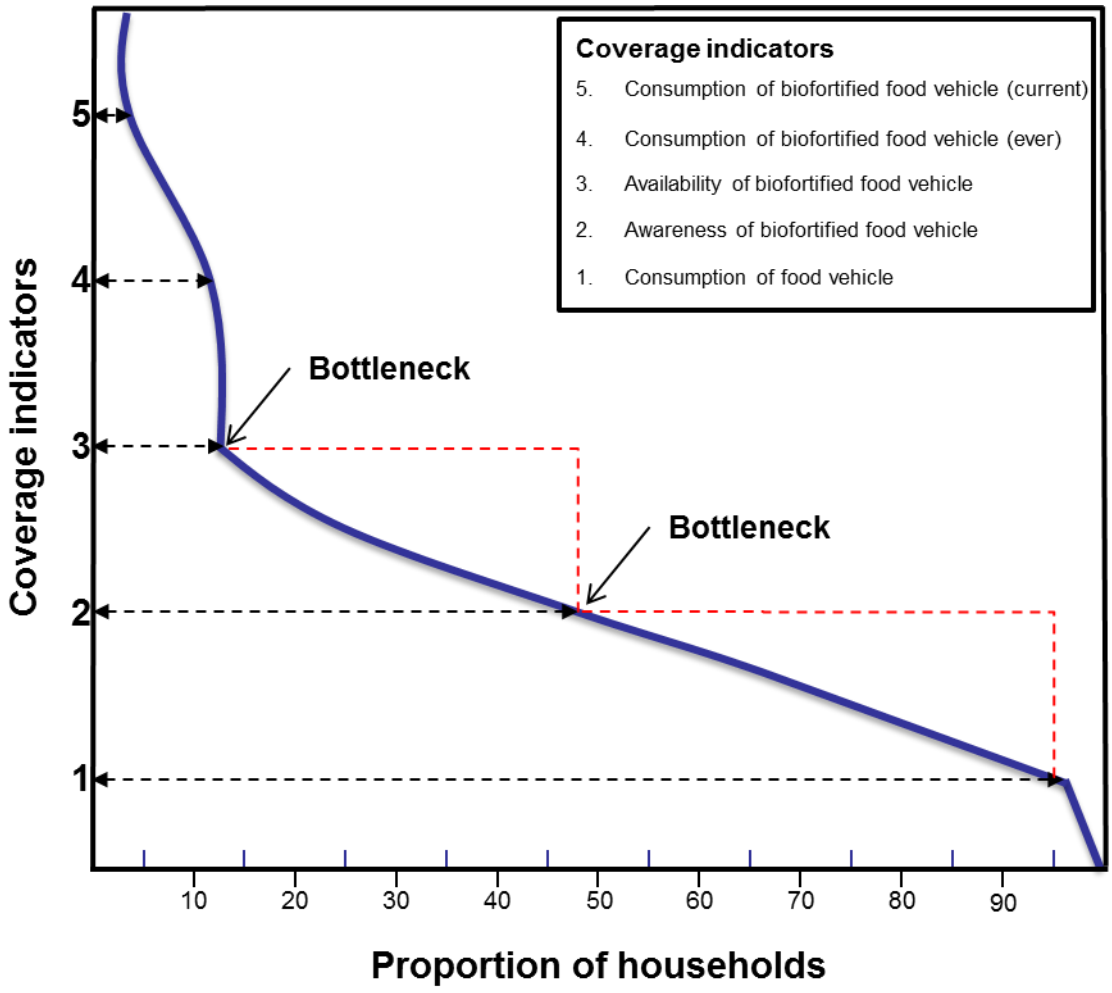


Figure 7. Coverage indicators for orange fleshed sweet potatoes by proportion of surveyed households

Similar to beans, a very large proportion of the surveyed households consumed sweet potatoes. Although not significant, the data suggests that fewer wealthy households consume sweet potatoes. Further, a larger proportion of households owning land consumed sweet potatoes compared to households that did not own land. Further, the proportion of

households consuming sweet potato was higher among households that grew the sweet potatoes compared to households that purchased sweet potatoes. No significant differences in sweet potato consumption were found between rural and peri-urban households as well as between households with female or male heads (Table 10 and Table 11).

Overall, about half of the households had ever heard of OFSP. Significantly more households that home grew sweet potatoes were aware of OFSP compared to those which bought sweet potatoes (72% vs. 42%; $p<0.001$). No significant associations were found between awareness of OFSP and any of the other investigated variables (Table 10 and Table 12). In contrast to beans, many of the respondents stated that they had heard of OSFP from the health extension worker (19.5%) and in the market or shop (17.8%; Table 26).

Although about half of the households had ever heard of OFSP, few households knew where to buy them (10.7%). Most of the households stated that OFSP were available in the market (73.1%) or from the farmer (42.3%; Table 26). A significantly higher proportion of those households that grew sweet potatoes knew where to buy OFSP, compared to those which did not grow sweet potatoes the last time they got them. No significant differences in OFSP availability was found for any of the other variables (Table 10 and Table 13).

About 10% of surveyed households had ever bought or obtained OFSP. Surprisingly, many of the households that reported having “ever bought” OFSP, did not know where to buy OFSP at the time of the survey (Table 13 and Table 14). In addition, few of the households that grew sweet potatoes had ever bought OFSP. Taste was the most frequently given answer when households were asked what they like about OFSP (46.6%), but was also given as a response by some households when asked what they *do not* like about OFSP (11.0%). Households also liked that OFSP were good for vitamin A status (33.1%), good for health in general (22.0%) and good for the eyes (18.6%; Table 26).

The overall household OFSP coverage was very low with about 2%, and no significant associations were found for any of the investigated variables (Table 10 and Table 15).

Table 10. Household coverage of orange-fleshed sweet potatoes in rural and peri-urban households

Indicator	Total			Peri urban			Rural			p-value
	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	
Household consumes sweet potatoes										
Yes	233	96.3	(93.0, 98.1)	81	94.2	(86.7, 97.6)	152	97.4	(93.3, 99.0)	0.203
No	9	3.7	(1.9, 7.0)	5	5.8	(2.4, 13.3)	4	2.6	(1.0, 6.7)	
Household is aware of OFSP [c]										
Yes	118	48.8	(42.5, 55.1)	44	51.2	(40.6, 61.6)	74	47.4	(39.7, 55.3)	0.580
No	124	51.2	(44.9, 57.5)	42	48.8	(38.4, 59.4)	82	52.6	(44.7, 60.3)	
Where respondent heard of OFSP? [d]										
Village/ community meetings	34	28.8	(21.3, 37.7)	14	31.8	(19.7, 47.0)	20	27.0	(18.0, 38.4)	0.581
Relatives/ friends/ neighbors	27	22.9	(16.1, 31.5)	10	22.7	(12.6, 37.6)	17	23.0	(14.7, 34.1)	0.976
Health extension workers	23	19.5	(13.2, 27.8)	10	22.7	(12.6, 37.6)	13	17.6	(10.4, 28.1)	0.468
Community leaders	9	7.6	(4.0, 14.1)	2	4.5	(1.1, 16.7)	7	9.5	(4.5, 18.7)	0.335
Women groups	6	5.1	(2.3, 11.0)	0	-		6	8.1	(3.6, 17.1)	0.051
Market place/ shop	21	17.8	(11.8, 25.9)	7	15.9	(7.7, 30.0)	14	18.9	(11.4, 29.6)	0.681
NGO	4	3.4	(1.3, 8.8)	1	2.3	(0.3, 14.8)	3	4.1	(1.3, 12.0)	0.601
Agricultural extension staff	7	5.9	(2.8, 12.0)	2	4.5	(1.1, 16.7)	5	6.8	(2.8, 15.4)	0.625
Projects (SUSTAIN/SASHA/FtF)	3	2.5	(0.8, 7.7)	2	4.5	(1.1, 16.7)	1	1.4	(0.2, 9.2)	0.291
Radio	12	10.2	(5.8, 17.2)	5	11.4	(4.7, 24.8)	7	9.5	(4.5, 18.7)	0.742
OFSP are available to household [e]										
Yes	26	10.7	(7.4, 15.3)	9	10.5	(5.5, 19.0)	17	10.9	(6.9, 16.9)	0.918
No	216	89.3	(84.7, 92.6)	77	89.5	(81.0, 94.5)	139	89.1	(83.1, 93.1)	
Where? [f]										
Shop	0	0.0	-	0	0.0	-	0	0.0	-	-
Farmer	11	42.3	(24.2, 62.8)	4	44.4	(16.4, 76.6)	7	41.2	(19.9, 66.3)	0.876
Market/street stand	19	73.1	(51.7, 87.3)	7	77.8	(39.4, 95.0)	12	70.6	(44.0, 88.0)	0.703
Moving street vendor	0	0.0	-	0	0.0	-	0	0.0	-	-

Table cont. on next page

Indicator	Total			Peri urban			Rural			p-value
	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	n	%[a]	95% CI [b]	
Household ever consumed OFSP [g]										
Yes	25	10.3	(7.1, 14.9)	8	9.3	(4.7, 17.6)	17	10.9	(6.9, 16.9)	0.697
No	217	89.7	(85.1, 92.9)	78	90.7	(82.4, 95.3)	139	89.1	(83.1, 93.1)	
Indicator 5 - Household currently consumes OFSP [h]										
Yes	5	2.1	(0.9, 4.9)	1	1.2	(0.2, 7.9)	4	2.6	(1.0, 6.7)	0.465
No	237	97.9	(95.1, 99.1)	85	98.8	(92.1, 99.8)	152	97.4	(93.3, 99.0)	

Note: The n's are un-weighted denominators for each subgroup
[a] Percentages are unweighted to account for equal probability of selection.
[b] CI=confidence interval, calculated taking into account the simple random sampling design.
[c] Households that reported not being aware of OFSP and households that reported not consuming sweet potatoes were classified as 'No'.
[d] Includes only households that were aware of OFSP; respondents were able to provide multiple responses
[e] Households that did not know where to buy/obtain OFSP and households that reported not consuming sweet potatoes were classified as 'No'
[f] Includes only households that knew where to buy/obtain OFSP; respondents were able to provide multiple responses
[g] Households that did not consume sweet potatoes and households that never consumed OFSP were classified as 'No'
[h] Households that did not consume sweet potatoes and household that did not consume OFSP at the time of the survey were classified as 'No'

Table 11. Indicator 1: Biofortified bean and sweet potato consumption by various household characteristics

Characteristic	Beans				Sweet potatoes			
	n	%[a]	(95% CI) [b]	p-value	n	%[a]	(95% CI) [b]	p-value
Residence								
Peri-urban	84	97.7	(91.1, 99.4)	0.057	81	94.2	(86.7, 97.6)	0.203
Rural	156	100.0	-		152	97.4	(93.3, 99.0)	
Sex of household head								
Female	66	98.5	(90.0, 99.8)	0.480	66	98.5	(90.0, 99.8)	0.256
Male	174	99.4	(96.0, 99.9)		167	95.4	(91.1, 97.7)	
Household owns land								
Yes	153	100.0	-	0.063	150	98.0	(94.1, 99.4)	0.056
No	87	97.8	(91.4, 99.4)		83	93.3	(85.7, 97.0)	
Wealth Quintile								
Lowest	48	98.0	(86.7, 99.7)	0.565	48	98.0	(86.7, 99.7)	0.070
Second	48	100.0	-		48	100.0	-	
Third	48	98.0	(86.7, 99.7)		48	98.0	(86.7, 99.7)	
Fourth	48	100.0	-		46	95.8	(84.7, 99.0)	
Highest	48	100.0	-		43	89.6	(77.2, 95.6)	
Last time household got crop it was homegrown								
Yes	103	100.0	-	0.222	58	100.0	-	0.098
No	137	98.6	(94.4, 99.6)		179	95.2	(91.0, 97.5)	

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 12. Indicator/ effect modifier 2: Biofortified bean and orange fleshed sweet potato awareness by various household characteristics

	Biofortified beans				Orange fleshed sweet potatoes			
Characteristic	**n**	**%[a]**	**(95% CI) [b]**	**p-value**	**n**	**%[a]**	**(95% CI) [b]**	**p-value**
Residence								
Peri-urban	60	69.8	(59.2, 78.6)	0.325	44	51.2	(40.6, 61.6)	0.580
Rural	99	63.5	(55.6, 70.7)		74	47.4	(39.7, 55.3)	
Sex of household head								
Female	42	62.7	(50.5, 73.4)	0.542	31	46.3	(34.7, 58.3)	0.633
Male	117	66.9	(59.5, 73.5)		87	49.7	(42.3, 57.1)	
Household owns land								
Yes	104	68.0	(60.1, 74.9)	0.331	77	50.3	(42.4, 58.2)	0.524
No	55	61.8	(51.3, 71.3)		41	46.1	(36.0, 56.5)	
Wealth Quintile								
Lowest	29	59.2	(45.0, 72.0)	0.262	21	42.9	(29.8, 57.0)	0.671
Second	27	56.3	(42.0, 69.5)		26	54.2	(40.0, 67.7)	
Third	33	67.3	(53.1, 79.0)		27	55.1	(41.0, 68.4)	
Fourth	36	75.0	(60.8, 85.3)		22	45.8	(32.3, 60.0)	
Highest	34	70.8	(56.5, 82.0)		22	45.8	(32.3, 60.0)	
Last time household got crop it was homegrown								
Yes	72	69.9	(60.3, 78.0)	0.238	39	72.2	(58.8, 82.6)	<0.001
No	87	62.6	(54.2, 70.3)		79	42.0	(35.1, 49.2)	

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 13. Indicator 3: Biofortified bean and orange fleshed sweet potato availability by various household characteristics

	Biofortified beans				Orange fleshed sweet potatoes			
Characteristic	**n**	**% [a]**	**(95% CI) [b]**	**p-value**	**n**	**% [a]**	**(95% CI) [b]**	**p-value**
Residence								
Peri-urban	25	29.1	(20.4, 39.6)	0.135	9	10.5	(5.5, 19.0)	0.918
Rural	32	20.5	(14.9, 27.6)		17	10.9	(6.9, 16.9)	
Sex of household head								
Female	16	23.9	(15.1, 35.6)	0.941	6	9.0	(4.1, 18.6)	0.580
Male	41	23.4	(17.7, 30.3)		20	11.4	(7.5, 17.1)	
Household owns land								
Yes	41	26.8	(20.3, 34.4)	0.121	14	9.2	(5.5, 14.9)	0.296
No	16	18.0	(11.3, 27.4)		12	13.5	(7.8, 22.3)	
Wealth Quintile								
Lowest	11	22.4	(12.8, 36.3)	0.608	5	10.2	(4.3, 22.4)	0.702
Second	8	16.7	(8.5, 30.0)		5	10.4	(4.4, 22.8)	
Third	15	30.6	(19.3, 44.9)		8	16.3	(8.3, 29.5)	
Fourth	11	22.9	(13.1, 36.9)		4	8.3	(3.1, 20.3)	
Highest	12	25.0	(14.7, 39.2)		4	8.3	(3.1, 20.3)	
Last time household got crop it was homegrown								
Yes	26	25.2	(17.7, 34.6)	0.595	12	22.2	(13.0, 35.3)	0.002
No	31	22.3	(16.1, 30.0)		14	7.4	(4.4, 12.2)	

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 14. Indicator 4: Biofortified bean and orange fleshed sweet potato acceptability by various household characteristics

	Biofortified beans				Orange fleshed sweet potatoes			
Characteristic	**n**	**% [a]**	**(95% CI) [b]**	**p-value**	**n**	**% [a]**	**(95% CI) [b]**	**p-value**
Residence								
Peri-urban	14	16.3	(9.8, 25.7)	0.752	8	9.3	(4.7, 17.6)	0.697
Rural	23	14.7	(10.0, 21.3)		17	10.9	(6.9, 16.9)	
Sex of household head								
Female	14	20.9	(12.7, 32.3)	0.136	6	9.0	(4.1, 18.6)	0.665
Male	23	13.1	(8.9, 19.1)		19	10.9	(7.0, 16.4)	
Household owns land								
Yes	27	17.6	(12.4, 24.6)	0.184	17	11.1	(7.0, 17.2)	0.602
No	10	11.2	(6.1, 19.7)		8	9.0	(4.5, 17.0)	
Wealth Quintile								
Lowest	7	14.3	(6.9, 27.2)	0.928	4	8.2	(3.1, 19.9)	0.926
Second	6	12.5	(5.7, 25.3)		4	8.3	(3.1, 20.3)	
Third	7	14.3	(6.9, 27.2)		6	12.2	(5.6, 24.8)	
Fourth	8	16.7	(8.5, 30.0)		6	12.5	(5.7, 25.3)	
Highest	9	18.8	(10.0, 32.4)		5	10.4	(4.4, 22.8)	
Last time household got crop it was homegrown								
Yes	15	14.6	(8.9, 22.8)	0.788	2	3.7	(0.9, 13.8)	0.071
No	22	15.8	(10.6, 22.9)		23	12.2	(8.2, 17.8)	

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 15. Indicator 5: Biofortified bean and orange fleshed sweet potato consumption by various household characteristics

	Biofortified beans				Orange fleshed sweet potatoes			
Characteristic	**n**	**% [a]**	**(95% CI) [b]**	**p-value**	**n**	**% [a]**	**(95% CI) [b]**	**p-value**
Residence								
Peri-urban	7	10.9	(5.3, 21.3)	0.864	1	1.2	(0.2, 7.9)	0.465
Rural	14	10.1	(6.1, 16.5)		4	2.6	(1.0, 6.7)	
Sex of household head								
Female	5	8.8	(3.7, 19.5)	0.637	3	4.5	(1.4, 13.1)	0.105
Male	16	11.0	(6.8, 17.3)		2	1.1	(0.3, 4.5)	
Household owns land								
Yes	14	9.9	(5.9, 16.1)	0.742	4	2.6	(1.0, 6.8)	0.434
No	7	11.5	(5.5, 22.3)		1	1.1	(0.2, 7.6)	
Wealth Quintile								
Lowest	4	9.5	(3.6, 22.9)	0.751				
Second	6	14.0	(6.4, 27.9)		0	-		0.396
Third	3	6.7	(2.1, 18.9)		2	4.2	(1.0, 15.3)	
Fourth	3	8.3	(2.7, 23.0)		2	4.1	(1.0, 15.0)	
Highest	5	13.9	(5.9, 29.5)		0	-		
Last time household got crop it was homegrown					1	2.1	(0.3, 13.5)	
Yes	9	9.2	(4.8, 16.8)	0.585	1	1.9	(0.3, 12.2)	0.900
No	12	11.5	(6.6, 19.3)		4	2.1	(0.8, 5.6)	

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

3.2.3 Cassava, cassava flour, maize and maize flour household coverage

As shown in Figure 8, other foods that could potentially be biofortified — cassava root, cassava flour, maize, maize flour — were consumed by the majority of households. Approximately 70% of household reported consuming cassava root, cassava flour, and maize flour. Fresh maize was consumed more than aforementioned foods, and about 9 out of 10 households reported consuming maize on the cob or maize grains. Significantly more peri-urban households consumed cassava root ($p<0.05$) and cassava flour ($p<0.01$) than rural households. Contrarily, more rural households consumed maize grain ($p<0.01$) and maize flour ($p=0.062$) than peri-urban households.

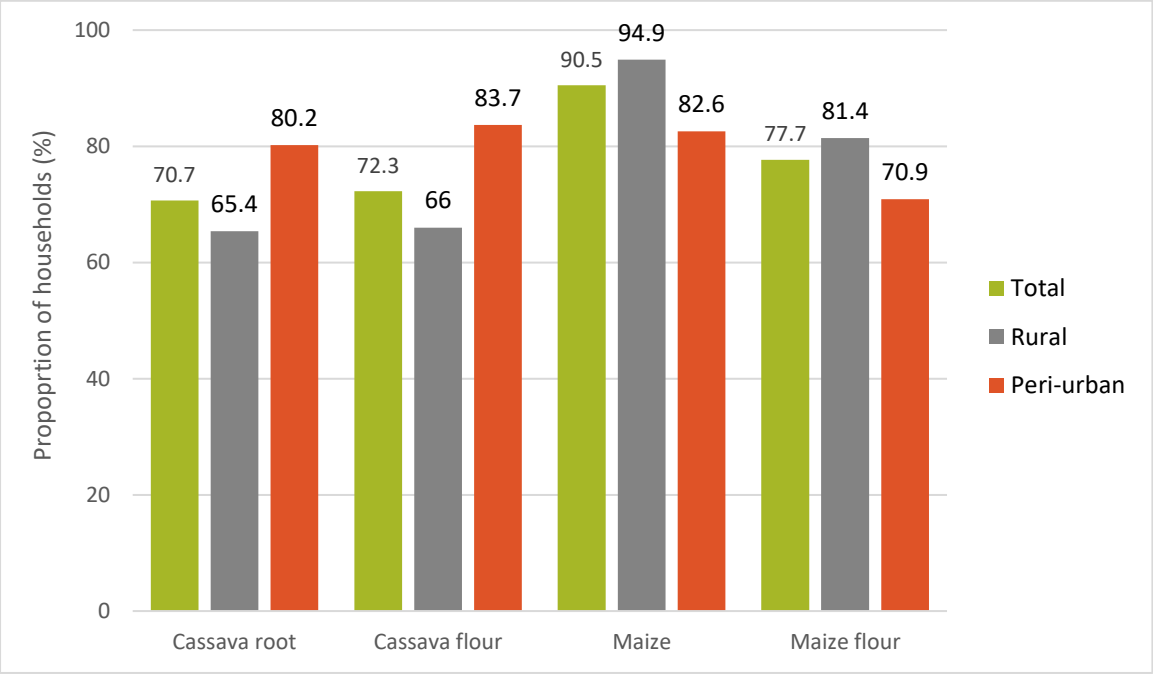


Figure 8. Proportion of households consuming various food vehicles (indicator 1)

3.3 Storage and processing practices of biofortified foods and potential foods for biofortification

Processing methods and storage conditions were assessed to estimate iron bioavailability and pro-vitamin A retention. Approximately 80% of households did not soak beans prior to cooking. Regarding preparation of sweet potato, 100% of household reported boiling as a cooking method. Detailed results for beans (Table 28), sweet potatoes (Table 29), cassava (Table 30), and maize (Table 31) are presented in Section 7.4.

3.4 Consumption and nutrient contribution of biofortified foods and consumption of other potential foods for biofortification

3.4.1 Beans

As shown in Table 16, 85 children resided in household consuming plausible quantities of beans. Mean daily intakes of conventional and biofortified beans among children were approximately 50 grams per day. Conventional bean intake tended to be higher in rural areas and poorer households compared to peri-urban areas and wealthier households, respectively. As the number of children consuming biofortified beans was very low, no precise estimate can be given for any biofortified bean sub-group analysis. In children, conventional beans provided 2.5 mg iron per day, which translates to 23.7% of the RNI of iron. Consuming biofortified beans increased the amount of available iron to 3.8 mg, equivalent to 34.4% of the RNI of iron (Table 16).

In women, mean daily intake was 125.8 grams for conventional beans and 119.9 grams for biofortified beans (see Table 17). The data suggests that bean intake was higher in poorer households compared to wealthier households. Conventional beans provided 6.3mg of iron per day, which is equivalent to 11.7% of the RNI of iron, whereas biofortified beans provided 10.1 mg, equivalent to 18.9% of the RNI of iron.

Table 16. Daily consumption of conventional and biofortified beans and corresponding iron intakes, children 6-59 months of age

	Conventional beans*				Biofortified beans*			
	n	Mean daily bean intake (g)	Mean daily iron intake (mg)	Mean % RNI of iron	n	Mean daily bean intake (g)	Mean daily iron intake (mg)	Mean % RNI of iron
Total	85	50.7	2.5	23.7	10	50.0	3.8	34.4
Residence								
Rural	63	51.4	2.6	24.0	7	57.1	4.8	44.3
Peri-urban	22	48.5	2.4	22.6	3	16.6	1.2	11.5
Wealth quintile								
Lowest	14	54.9	2.7	26.2	1	97.9	7.3	63.3
Second	19	60.2	3.0	27.7	3	39.8	3.2	30.2
Third	22	47.7	2.4	22.2	2	64.9	6.5	62.5
Fourth	15	44.4	2.2	20.8	1	52.5	3.9	31.2
Highest	15	45.1	2.3	21.1	3	16.7	1.2	11.5

Note: The n's are un-weighted numbers in each subgroup; the sum of subgroups may not equal the total because of missing data.
* Type of bean determined by expert analysis of bean samples collected as part of survey. Results of bean analysis were available for 84% (n=202) of the surveyed households

Table 17. Daily consumption of conventional and biofortified beans and corresponding iron intakes, women 15-49 years of age

	Conventional beans*				Biofortified beans*			
	n	Mean daily bean intake (g)	Mean daily iron intake (mg)	Mean % RNI of iron	n	Mean daily bean intake (g)	Mean daily iron intake (mg)	Mean % RNI of iron
Total	228	125.8	6.3	11.7	24	119.9	10.1	18.9
Residence								
Rural	151	126.8	6.3	11.8	14	135.3	10.9	20.2
Peri-urban	77	123.8	6.2	11.5	10	98.3	9.0	16.9
Wealth quintile								
Lowest	46	165.2	8.3	15.1	4	173.9	13.0	23.9
Second	41	147.6	7.4	13.7	8	87.5	6.9	13.0
Third	50	99.8	4.9	9.4	2	139.5	13.9	26.4
Fourth	47	105.4	5.3	10.0	4	91.9	7.2	12.9
Highest	44	115.7	5.8	10.9	6	139.2	13.2	24.7

Note: The n's are un-weighted numbers in each subgroup; the sum of subgroups may not equal the total because of missing data.
* Type of bean determined by expert analysis of bean samples collected as part of survey. Results of bean analysis were available for 84% (n=202) of the surveyed households

3.4.2 Sweet potatoes

As shown in Table 18, 87 children 6-59 months of age resided in households consuming plausible amounts of conventional sweet potatoes. These children had an estimated consumption of 228 grams per day, with consumption significantly (p=0.012) higher in rural areas. Consumption of conventional sweet potatoes among children 6-23 months (n=31) was 182.8 grams (95% CI: 156.6, 209.1), and among children 24-59 months (n=56) was 253.1 grams (95% CI: 229.1, 277.1) (data not shown). Although white sweet potatoes contain only small amounts of pro-vitamin A, the quantity consumed resulted in modest intakes of RE, that accounted for approximately 8% and 10% of RNI and EAR of vitamin A, respectively.

Only three children 6-59 months of age resided in households consuming OFSP, and average consumption by these three children was similar (~225 grams/day) to the consumption of children consuming white sweet potatoes. The households of these three children, however, reported that their last sweet potato purchase contained both orange and white varieties, with a low proportion (20%-30%) of the sweet potatoes orange fleshed (data not shown). This resulted in a consumption of approximately 445ug RE, and a %RNI and %EAR of approximately 110% and 150%, respectively. No sub-group analysis was conducted as all three children resided in rural areas.

For women 15-49 years of age, mean daily consumption of conventional sweet potatoes was nearly 500 grams per days, and their consumption was significantly higher ($p<0.01$) in peri-urban areas (see Table 19). Consumption of OFSP was higher than conventional sweet potatoes, particularly in peri-urban areas. Among the 3 women consuming OFSP in peri-ubran areas, the consumption of OFSP was more than 300 grams higher that conventional sweet potato consumption in the same areas. Among women consuming OFSP, consumption was significantly higher ($p<0.001$) in peri-urban areas.

As shown in Table 19, 214 women resided in households consuming plausible quantities of sweet potatoes. Women consumed OFSP in greater quantities compared to women consuming conventional sweet potatoes only. On average, women that consumed OFSP consumed nearly 3000 µg RE per day. However, significant differences were found by residence, with women in peri-urban areas receiving an intake of nearly 5500 µg RE. This difference is due to the fact that all three women residing in peri-urban areas resided in households that exclusively purchased OFSP (data not shown). Conversely, the four women in rural areas resided in households that reported purchasing both white sweet potatoes and OSFP, with OSFP accounting for only 20-30% of the sweet potatoes consumed by the household. For this reason, intake of vitamin A (RE ug) from OFSP was significantly higher ($p<0.001$) in women in peri-urban areas and resulted in correspondingly higher levels of %RNI and %EAR. Though based on a very small sample size, the results illustrate that even modest purchases of OSFP can results in RE intakes that exceed the RNI and EAR requirements.

Table 18. Daily consumption of conventional sweet potatoes and orange fleshed sweet potatoes and corresponding vitamin A intakes, children 6-59 months of age

	Conventional sweet potato*				Orange fleshed sweet potato*‡			
	n	Mean daily sweet potato intake (g)	Mean daily Vitamin A intake RE (ug RE)	Mean % EAR and RNI of vitamin A	n	Mean daily sweet potato intake (g)	Mean daily Vitamin A intake RE (ug RE)	Mean % EAR and RNI of vitamin A
Total	87	228.1	32.3	7.9 (RNI) 10.9 (EAR)	3	222.8	444.5	111.1 (RNI) 155.4 (EAR)
Residence								
Rural	58	244.4	34.6	8.4 (RNI) 11.8 (EAR)	-	-	-	-
Peri-urban	29	195.4	27.7	6.7 (RNI) 9.4 (EAR)	-	-	-	-

Note: The n's are un-weighted numbers in each subgroup; the sum of subgroups may not equal the total because of missing data.
* Questionnaire designed to prompt interviewers to visually observe sweet potatoes from the last purchase. However, all households that reported purchasing orange-fleshed sweet potatoes (n=2) or a mixture of white- and orange-fleshed sweet potatoes (n=3) did not have any sweet potatoes remaining to show the interviewer.
‡ Only 3 children 6-59 months of age resided in households consuming orange fleshed sweet potato, and all household last purchasing both orange and white varieties. No sub-group analysis was conducted as all 3 children resided in rural areas.

Table 19. Daily consumption of conventional sweet potatoes and orange fleshed sweet potatoes and corresponding vitamin A intakes, women 15-49 years of age

	Conventional sweet potato*				Orange fleshed sweet potato*‡			
	n	Mean daily sweet potato intake (g)	Mean daily Vitamin A intake RE (ug RE)	Mean % EAR and RNI of vitamin A	n	Mean daily sweet potato intake (g)	Mean daily Vitamin A intake RE (ug RE)	Mean % EAR and RNI of vitamin A
Total	214	495.6	70.2	14.0 (RNI) 19.7 (EAR)	7	635.9	2945.9	589.2 (RNI) 825.2 (EAR)
Residence								
Rural	133	521.6	73.9	14.8 (RNI) 20.7 (EAR)	4	534.3	1057.9	211.6 (RNI) 296.3 (EAR)
Peri-urban	81	452.8	64.2	12.8 (RNI) 17.9 (EAR)	3	771.3	5463.2	1092.6 (RNI) 1530.3 (EAR)

Note: The n's are un-weighted numbers in each subgroup; the sum of subgroups may not equal the total because of missing data.
* Questionnaire designed to prompt interviewers to visually observe sweet potatoes from the last purchase. However, all households that reported purchasing orange-fleshed sweet potatoes (n=2) or a mixture of white- and orange-fleshed sweet potatoes (n=3) did not have any sweet potatoes remaining to show the interviewer.
‡ Of the 7 women 15-49 years of age resided in households consuming orange fleshed sweet potato, 3 women were in households consuming orange-fleshed sweet potato and 4 were in households consuming both orange and white varieties.

3.4.3 Estimated consumption per AME of all staple foods

Figure 9 presents the estimated daily consumption per AME of beans, sweet potatoes, cassava root, cassava flour, maize grain, and maize flour. The mean consumption was significantly higher in rural areas for beans ($p<0.05$), sweet potatoes ($p<0.01$), cassava flour ($p<0.05$), and maize flour ($p<0.01$) (data not shown). No significant differences in consumption of cassava root and maize grain were found by residence.

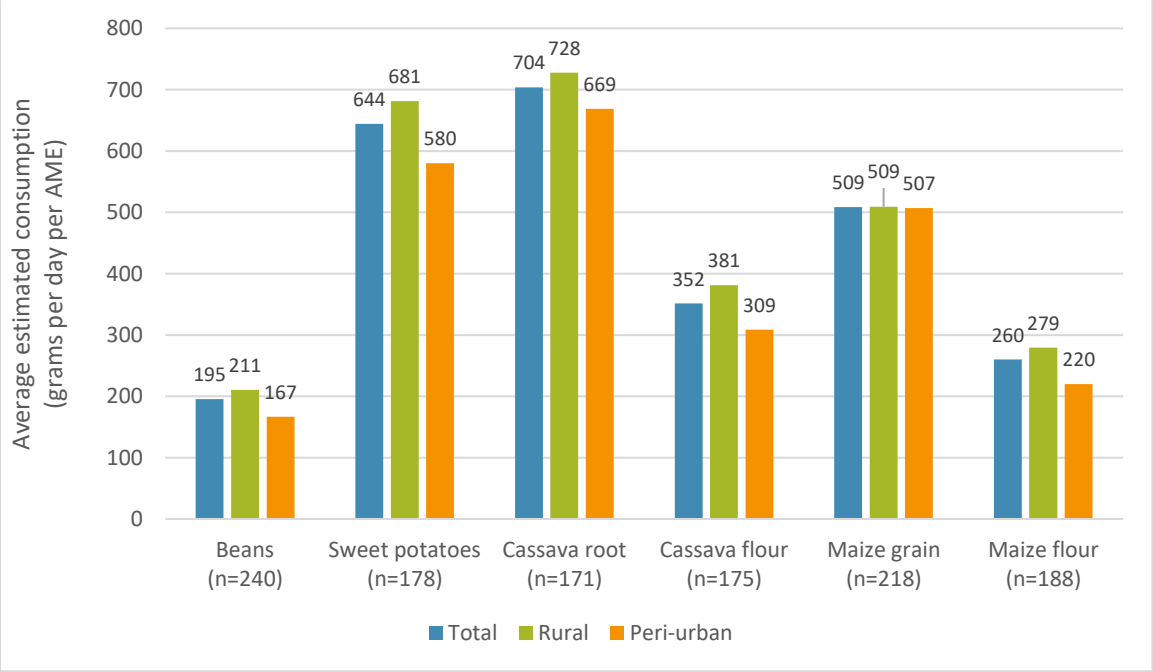


Figure 9. Estimated consumption of beans, sweet potatoes, cassava, cassava flour, maize, and maize flour in grams per day per AME (estimates use only households consuming the respective food vehicle)

4 DISCUSSION

4.1 Assessing coverage of biofortified foods

4.1.1 Method development

We developed a set of universally-applicable indicators to assess the coverage of biofortification programs. The indicators can be used to assess the coverage of biofortified foods with visible and non-visible traits after being adapted to the food of interest. This tool was based on GAIN's FACT coverage survey questionnaire and used a modified version of the Tanahashi model [14,33].

As the FACT questionnaire was designed for large-scale food fortification (LSFF), some important modifications to the model were needed to account for important differences between LSFF and biofortification. In both LSFF and biofortification, the first indicator in the Tanahashi model of coverage is the same: the consumption of the food in any form (biofortified or conventional). Apart from this indicator, the LSFF Tanahashi model [33] and the biofortification Tanahanshi model vary considerably. The LSFF model is based on the fact that LSFF programs are essentially implemented at the level of industrial food producers, such as flour mills and oil refineries. In addition, the micronutrients added by LSFF programs are invisible, and oftentimes mandated. As such, consumers do not have to visibly differentiate fortified and non-fortified products, and the price of industrially-fortified foods will not deter purchase and consumption, particularly when LSFF programs are mandated. Thus, indicators in the LSFF Tanahashi framework, such as the *coverage of fortifiable food* and *consumption of fortified food* are not directly comparable to the biofortification Tanahashi framework.

The biofortification framework's fifth coverage indicator (i.e. current consumption of the biofortified food) is analogous to the LSFF framework's indicator *consumption of adequately fortified food*. Biofortified foods are, by default, "adequately" biofortified. Assessment of household consumption of biofortified foods can be determined objectively through visual assessment by the interviewer at the household for biofortified foods with visible traits, e.g. OFSP. For biofortified foods with non-visible traits that remain nearly identical to the conventional version, visual confirmation is possible in some cases by breeding experts (e.g. bean experts) or by farmers familiar with peculiar plant and/or pod characteristics. This visual expert inspection may not, however, be feasible for other crops (e.g. rice, wheat, pearl millet, white zinc maize). In these cases, quantitative laboratory testing may be needed for confirmation if the crop is biofortified or not.

To address this important gap in the coverage cascade for food biofortification between consumption of the food vehicle and consumption of the biofortified food vehicle, we included three additional indicators aimed at understanding the drivers of consumption and to provide additional information for identifying bottlenecks to scale. These are awareness, availability and consumption of the biofortified food (ever). Fundamentally, households that

consume the conventional food or product made from the food are required, in most circumstances, to be aware of the biofortified alternative and for it to be available either for home growing or purchase through the market. However, availability in the community or within the household does not necessarily translate to consumption among individuals [34] since contact with the biofortified food (ever consumed), a positive experience with the crop (e.g. yield in case of farming households) and/or food acceptance (e.g. sensory attributes, cooking behaviour, nutritional or health benefits) are critical for consumers to consume the food regularly. It is also important to note that certain linkages within the PIP for biofortified foods will be more or less important in different food systems and dietary pattern contexts. For example, awareness may or may not be a prerequisite to delivery models depending on the maturity of the program (e.g. early adoption versus mainstreamed) and whether the biofortified food has non-visible or visible traits of being biofortified. With non-visible traits, the biofortified food is otherwise indistinguishable from the conventional varieties making awareness a less important part of the PIP. Alternatively, if the biofortified food has visible and perhaps unfamiliar traits (e.g. changes in colour, taste or texture), additional information will have to be provided to consumers via strategies such as behavior change communication (BCC) to communicate the benefits of the biofortified varieties. As such, awareness can be a part of the PIP or an effect modifier translating availability to uptake. It should be noted that these additional indicators can also be used in LSFF programs but are less important given the ability to easily assess consumption of the fortifiable and fortified foods and use that information to identify critical bottlenecks in the program delivery.

Further, a problem which is unique for beans is the fact that households buy different varieties with one purchase and thus a certain proportion of households had more than one bean variety available. Collecting several samples from a single household would pose multiple problems and would complicate the estimation of coverage indicator 5. Thus, if an interviewer were to find a household that has multiple varieties of beans, it is suggested that for beans a consolidated bean sample should be taken and an equal ratio between biofortified and conventional beans should be assumed.

Of note, the tool was developed to assess the consumption coverage of biofortified foods, either bought or harvested. There is increasing focus on adding biofortified foods as ingredients to food products (e.g. biscuits produced with OFSP root flour) to better access urban households and harder-to-reach households with biofortified foods. Thus, depending on the setting, future surveys might have to include questionnaire modules assessing purchase of food products which have biofortified foods as ingredients.

To optimize and further inform the questionnaire, two formative research activities (FGDs and a market research survey) were conducted prior to the survey. Initially those activities were meant to be used only for the tool development, but as they yielded important country-specific information on biofortified foods (e.g. local names of the different biofortified foods, cooking practices etc.), we suggest that those activities be conducted prior to any

biofortification coverage survey. Both activities are easy to design and implement, and results from the FGDs and market visits can be used to decide whether or not to conduct a household-coverage survey, which is more time-consuming and costly. In the case of OFSP in Rwanda, the market visits and focus group discussions indicated that OFSP were not widely available to the vendors and also to the consumers, which was confirmed by the actual survey results (household coverage of about 2%). In such a case, the household coverage survey could have been cancelled or delayed until programmatic issues related to supply of OFSP were solved.

The proportional piling method was used to assess proportions of biofortified beans and OFSP for mixed purchases, as well as different proportions of food processing techniques. In general, the method was well accepted and easy to implement. Although most households surveyed in Rwanda did not consume OFSP, pro-vitamin A biofortified foods, such as OFSP, orange cassava, or orange maize are widely distributed in many other countries. Due to the instability of pro-vitamin A, and its degradation during storage and processing of sweet potatoes, maize, and cassava, the proportional piling method can be particularly useful when this methodology is applied to settings where pro-vitamin A biofortified foods are widely consumed. The proportional piling method, however, was not useful for estimating the proportion of conventional and biofortified beans in mixed purchases consumed by the household since household respondents were not able to distinguish between conventional and biofortified varieties.

4.1.2 Method testing

In Musanze, almost all households were found to consume beans and sweet potatoes, which validates the premise of biofortification, i.e. targeting key staples that are consumed regularly by all households [35]. However, the biofortified bean and OFSP coverage (i.e. current consumption of the biofortified foods) was relatively low; and awareness and availability of biofortified beans and OFSP were identified as the main bottlenecks. Despite the large drop from consumption of the foods in any form (indicator 1) to awareness of the biofortified food (indicator 2), awareness figures are respectable for IB and OFSP whose seeds were introduced as recently as 2012. In biofortification, the utility of the awareness indicator varies largely depending on the nature of the food vehicle. For beans, awareness might not necessarily be a prerequisite for promoting consumption as a large proportion of households did not know that they were consuming biofortified beans. On the other hand, the higher price of biofortified beans was identified as one of the reasons bean vendors did not sell biofortified varieties rendering awareness creation a necessity to increase consumers' willingness to pay more and with it drive the demand for biofortified beans. A study conducted in Rwanda indicated that people might be willing to pay more for certain biofortified bean varieties [36]; however, strategies to lower the price of biofortified varieties, in addition to awareness creation, also need to be explored. That said, if biofortified varieties with non-visible traits were mainstreamed (meaning they replaced all conventional varieties available in the market)

or if biofortified varieties had superior production characteristics (e.g. higher yield or disease resistance), awareness creation or education on the benefits may not be needed. For OFSP, which are visibly different than other sweet potato varieties, awareness has been shown to be a driver of consumption/adoption aside from other factors such as organoleptic characteristics, taste preferences, access to planting material etc. [37]. To further increase awareness, awareness campaigns and other information sharing efforts targeting consumers and farmers could be implemented, and could likely have a beneficial effect on the adoption rate and demand creation [35,38,39]. Those campaigns could include BCC activities to promote the production and consumption of biofortified crops, as well as educational activities and messages related to positive health behaviours and child care and feeding practices [7].

The main bottleneck to coverage of both biofortified foods was their availability; only about every fifth and every tenth household reported knowing where to buy/obtain IB or OFSP, respectively. Biofortification of staple foods can be regarded as a sustainable approach if the delivery model also involves developing new markets by adding value through the development of new products [40]. However, sustained consumption is influenced most directly by ensuring a consistent supply of planting material and demand for the biofortified food [34]. Thus, it should be evaluated if seed multiplication and delivery systems are still functioning such that consumer demand can be satisfied.

A limitation of our study was that not all households had beans at home at the time of the survey and only 84% of the households provided a bean sample. Since respondents could not identify biofortified beans, only households that provided a sample were included in the analysis of this indicator. Therefore, the indicator on consumption of the biofortified food (currently) may be slightly under or overestimated, as households that did not provide a bean sample were excluded from the analysis. Future surveys should consider arranging for field workers to make repeated visits to households in order to get a sample from all households.

4.2 Estimating nutrient contributions (%RNI, % EAR) of biofortified foods

4.2.1 Method development

Prior to estimating vitamin or mineral intake, %RNI, or %EAR, the individual food consumption must be calculated. In Rwanda, the AME approach worked well for calculating each individual's percent of the household's consumption (% of total household AME). However, we experienced some challenges to reliably estimate the daily household consumption of beans and sweet potatoes. For beans, asking the household respondent about the amount of beans bought during the last purchase, and how long these beans lasted, produced reasonable and plausible consumption estimate for most households. For a small proportion of households, implausible values were obtained, and these outlier households — and the household members within — had to be excluded from estimates of individual consumption.

Since only a small number of households were excluded, the impact of this measurement error on the overall results was negligible.

For sweet potatoes, the same approach of collecting data on quantity of sweet potatoes obtained during the last purchase (and how long this food lasted) yielded a higher proportion of households with implausible consumption values. It appeared that the respondent did not completely understand the question asking how often the food purchased lasted. For example, there were many cases where households reported that the last purchase of sweet potatoes was 10 kilograms, but then responded that this amount lasted only one day. Using food balance sheet data to develop an implausible consumption level (see Section 2.3.2) provided an objective threshold, and results in the exclusion of only 12% of households. Ultimately, the estimates of conventional sweet potato consumption was approximately 500 grams per day, which is similar to per-capita estimates of 441 grams per day based on FAO food balance sheet data [22] and national surveys that measured the proportion of households that consumed sweet potatoes.

While this consumption estimation approach worked adequately in Rwanda, this method is error prone as it is based on the respondent's ability to accurately remember the quantity of the last purchase and the time that purchase lasted. However, it is possible that in future surveys a significant number of households might have to be excluded due to wrong reporting of respondents. In order to avoid the loss of data due to implausible values we suggest putting more research into the programming of electronic data collection tools. Electronic tools could be programmed to flag implausible values during data collection allowing the interviewer to challenge the answers of the respondent during the interview.

Estimating consumption from recent household purchase has an important limitation, as it does not account for food consumed outside of the household. The level of consumption of outside the home can vary substantially by locale, and should the majority of the consumption of biofortified foods for key population groups occur outside the home, additional approaches would need to be developed.

Using consumption estimates and established RNIs, the %RNI of iron and vitamin A were calculated. However, accurate estimation of the bioavailability of iron is indispensable to correctly calculate the contribution of biofortified foods to the RNI. Bioavailability levels will have to be chosen carefully as they substantially impact the calculation of the contribution of the biofortified food to the RNI. For iron, we chose to use different bioavailabilities/ RNIs based on the bean processing methods (5%, 6%, 8%) used by the households. Importantly, bioavailability depends on other meal components and dietary practices (e.g. drinking tea during meals), and thus estimating the exact and constant bioavailability for an individual is impossible. All non-heme iron in a meal enters a common iron pool and the bioavailability depends on the concentration of inhibitors and enhancers in the meal. We used 5%, 6% and 8% bioavailability since it has been shown that iron bioavailability from biofortified beans ranges between 4%-7%, when consumed with cooking water and eaten in combination with

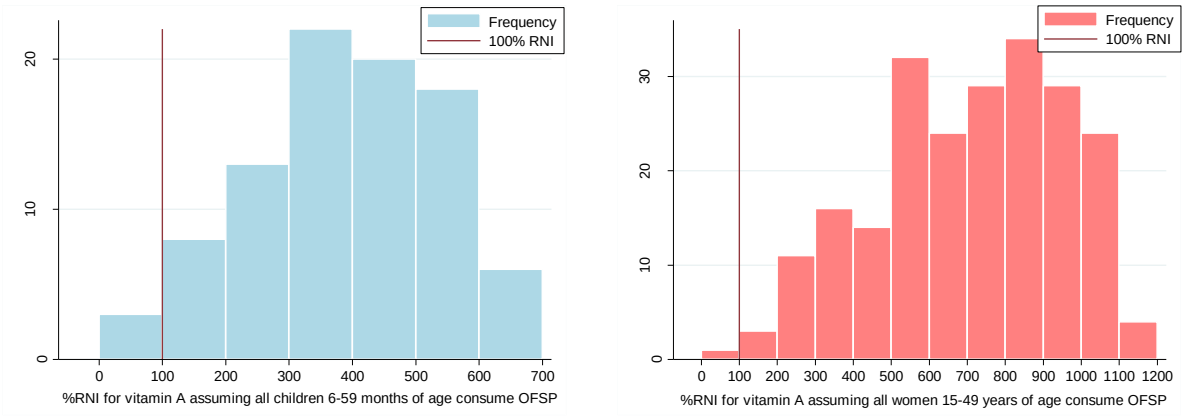
rice or Irish potatoes. But a large proportion of polyphenols, which belong to the main inhibitors of iron absorption, are discarded when the soaking water is not used and thus bioavailability could be expected to slightly increase. However, higher bioavailabilities will have to be applied when beans are eaten with foods rich in vitamin C or citric acid, such as fruits and vegetables or with meat. On the other hand, absorption would be lower if beans are eaten in combination with other foods high in phytic acid and polyphenols. It has been suggested to use an iron bioavailability of 1-9% for diets based on cereals, roots or tubers, with negligible amounts of meat, fish, poultry or ascorbic acid-rich foods and high in foods that inhibit iron absorption such as maize, beans, whole wheat flour and sorghum [2].

Since absorption of minerals from biofortified foods depends on various factors and are hard to predict, we would suggest calculating their contribution to the RNI using different bioavailabilities/ RNIs.

4.2.2 The contribution of biofortified beans and OFSP to the RNI of children and women in Rwanda

The results show that biofortified beans make a meaningful contribution to filling the nutrient gap in women and children by providing on average one-fifth and one-third of the % RNI, respectively. We assumed an iron bioavailability of 5-9% to calculate bean iron absorption depending on the bean preparation. However, iron absorption depends on many factors such as a) the iron status of the individual; b) the concentration of iron absorption inhibitors, such as polyphenols and phytic acid in the bean itself and in other meal components and c) the concentration of iron absorption enhancers, such as vitamin C in other meal components and d) the preparation of the meal. Consequently bean iron absorption has been reported to vary widely, between below 1% to about 9% [21]. That said, despite a clear indication that biofortified beans provide a significant additional amount of iron in Rwanda, the % contribution to the RNI calculated above should be used with caution.

In total, only 7 surveyed women and 3 surveyed children resided in households that consumed OFSP. While this small sample size cannot be considered representative, the OFSP consumption data nonetheless indicates that OFSP have the potential to provide significant amounts of pro-vitamin A to target populations. To assess the potential impact of OFSP with a higher precision, we have calculated the hypothetical %RNI that would be obtained if all children and women replaced all consumption of conventional sweet potatoes with OFSP (see Figure 10). In this hypothetical scenario, OFSP would provide ≥100% of the RNI of vitamin A for nearly all children 6-59 months of age (n=90) and women 15-49 years of age (n=221); only three children and one woman would have %RNI less than 100%.



(A) (B)

Figure 10. Hypothetical %RNI of vitamin A from OFSP using sweet potato consumption data, in children 6-59 months (A) and women 15-49 years of age (B)

5 RECOMMENDATIONS

5.1 Test coverage indicators in other contexts

The results of our study fill a gap in the tools available to assess the coverage of biofortified foods and to identify program implementation bottlenecks. Further testing of the tool is needed to confirm the generalizability of the indicators when applied to different countries and foods. Examining the utility of the coverage indicators for different biofortified foods in various countries is essential to help stakeholders identify and address challenges to scale and increase the coverage of biofortified foods.

5.2 Implement pre-survey activities

It is suggested that both market surveys and FGDs be conducted prior to fielding a household-based biofortification coverage survey. Market surveys and FGDs are easy to design and implement, and should they indicate low distribution (from market vendors) and little household direct consumption (from FGDs), researchers could postpone or cancel the household-based survey, as the investment of time and resources to design and implement a household-based survey would not be warranted. To make objective decisions about whether or not a household-based survey should be conducted, researchers should establish, *a priori*, the thresholds required from the market survey and FGDs.

5.3 Improved food consumption estimates with enhanced electronic questionnaire programming

To improve estimates of individual consumption, electronic data collection tools that analyze food purchase and use data should be developed and tested. While the programming in ODK for the Rwanda household survey was quite sophisticated, there are additional functionalities in ODK that could be explored that could potentially be used to a) calculate total household AMEs, b) flag consumption estimation errors, and c) estimate daily consumption for each member of the household. Additional functionality could considerably increase data quality and reduce the amount of observations discarded from analysis due to implausible values.

5.4 Utilize proportional piling method

The proportional piling method is an easy-to-use approach to help respondents estimate proportions. This approach was used at various times in the Rwanda household questionnaire, and it was well accepted, and provided data that was used directly to estimate individual daily consumption of biofortifiable foods and subsequently, the calculation of %RNI and %EAR. As this approach is not routinely used in coverage surveys, it is recommended that this approach be utilized in future surveys to estimate proportion of biofortified food purchase of total staple (e.g. what proportion of sweet potatoes purchased were orange fleshed sweet potatoes?), and to estimate proportions related to food processing methods and storage conditions.

5.5 Sample collection for biofortified foods with non-visible traits

For future coverage surveys including a target biofortified food with non-visible traits, it is recommended that researchers collect a food sample from each household, and have this sample reviewed by a breeding specialist to determine if each sample is a biofortified or conventional variety. If breeding specialists cannot visibly determine a food's variety and ascertain if it is biofortified, laboratory analysis of the food sample should be considered.

5.6 Use multiple bioavailabilities/RNIs to calculate contribution of biofortified foods

As it is nearly impossible to determine concretely which WHO RNI or EAR bioavailability classification should be used for iron or zinc, it is recommended that the % RNI and % EAR provided by biofortified foods should be calculated using different bioavailabilities / RNIs. Since absorption of minerals from biofortified foods depends on various factors and are hard to predict, choosing two likely scenarios could provide a range of the % RNI of iron or zinc delivered by the biofortified food. A range of % RNI received from biofortified foods would be useful for program planners and researchers, and reduce the risk of over- and under-estimation of program impact.

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7 SUPPLEMENTARY TABLES

7.1 Household demographics

Table 20. Distribution of various demographic variables for participating households

Characteristic	n	%, mean, median [a]	(95% CI) [b]
Total surveyed households	242	100.00	-
Residence (%)			
Rural	156	64.5	(58.2, 70.3)
Peri-urban	86	35.5	(29.7, 41.8)
Sex of household head (%)			
Male	175	72.3	(66.3, 77.6)
Female	67	27.7	(22.4, 33.7)
Average household size			
Mean	242	4.3	(4.1, 4.5)
Median	242	4	(3.7, 4.3)
Number of household members (%)			
1	9	3.7	(1.9, 7.0)
2	22	9.1	(6.0, 13.5)
3	55	22.7	(17.8, 28.5)
4	51	21.1	(16.4, 26.7)
5	55	22.7	(17.8, 28.5)
6 or more	50	20.7	(16.0, 26.3)
Number of women 15-49 years of age in households (%)			
0	37	15.3	(11.3, 20.4)
1	146	60.3	(54.0, 66.3)
2	39	16.1	(12.0, 21.3)
3	13	5.4	(3.1, 9.1)
4	6	2.5	(1.1, 5.4)
5	1	0.4	(0.1, 2.9)
Number of children 6-59 months in households (%)			
0	144	59.5	(53.2, 65.6)
1	82	33.9	(28.2, 40.1)
2	14	5.8	(3.4, 9.6)
3	2	0.8	(0.2, 3.3)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 21. Distribution of water and sanitation variables for participating households

Characteristic	n	%[a]	(95% CI)[b]
Main source of water for drinking[c]			
Improved source	228	94.2	(90.4, 96.6)
Unimproved source	14	5.8	(3.4, 9.6)
Treat water to make safe to drink			
No	94	38.8	(32.9, 45.2)
Yes	148	61.2	(54.8, 67.1)
Water treatment			
Boil	139	93.9	(88.6, 96.8)
Add bleach or chlorine	5	3.4	(1.4, 7.9)
Strain it through a cloth	0	0.0	-
Use a water filter	0	0.0	-
Solar disinfection	0	0.0	-
Let it stand and settle	0	0.0	-
Purification tablet	0	0.0	-
Drink safe water[d]			
No	8	3.3	(1.7, 6.5)
Yes	234	96.7	(93.5, 98.3)
Household sanitation[e]			
Adequate	103	42.6	(36.4, 48.9)
Inadequate	139	57.4	(51.1, 63.6)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Improved source = water from piped system, tube well or borehole, protected well, protected spring, rainwater collection, bottled water or sachet water. Unimproved source = water from unprotected well, unprotected spring, tanker truck or cart, surface water or other.

[b] Composite variable of main source of drinking water and treating water to make safe for drinking

[e] Composite variable of toilet type and if toilet facilities are shared with non-household members; Adequate Sanitation = flush or pour flush toilet or pit latrine with slab not shared with another household. Inadequate sanitation= open pit, bucket latrine, hanging toilet/latrine, no facility, bush, field.

Table 22. Distribution of cooking fuel variables for participating households

Characteristic	n	%[a]	(95% CI)[b]
Type of fuel used for cooking			
Electricity	1	0.4	(0.1, 2.9)
Liquefied petroleum gas	6	2.5	(1.1, 5.4)
Charcoal	56	23.1	(18.2, 28.9)
Wood	175	72.3	(66.3, 77.6)
Straw, shrubs, or grass	4	1.7	(0.6, 4.3)
TOTAL RESPONDING HOUSEHOLDS	242	100.0	-

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 23. Proportion of livestock and agriculture variables for participating households

Characteristic	n	%[a], median	(95% CI)[b]
Member of household owns any agricultural land			
No	89	36.8	(30.9, 43.1)
Yes	153	63.2	(56.9, 69.1)
If own land, median amount (in hectares)			
Household owns any livestock			
No	138	57.0	(50.7, 63.2)
Yes	104	43.0	(36.8, 49.3)
Household owns livestock, specific [a]			
Cattle	24	23.1	(15.9, 32.3)
Cows for milk	37	35.6	(26.9, 45.4)
Horses, donkeys, mules	0	0.0	-
Goats	18	17.3	(11.1, 26.0)
Sheep	23	22.1	(15.1, 31.3)
Rabbits	9	8.7	(4.5, 16.0)
Pigs	21	20.2	(13.5, 29.2)
Chicken	29	27.9	(20.0, 37.4)
Other poultry	0	0.0	-

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Question only asked to households responding "Yes" to livestock ownership

Table 24. Distribution of handwashing variables for participating households

Characteristic	n	%[a]	(95% CI)[b]
Location of handwashing site			
Observed	60	24.8	(19.7, 30.7)
Not in dwelling / plot / yard (not observed)	179	74.0	(68.0, 79.1)
Permission to see handwashing area not given	3	1.2	(0.4, 3.8)
Water is available at observed handwashing place [a]			
No	20	33.3	(22.3, 46.5)
Yes	40	66.7	(53.5, 77.7)
Soap seen at handwashing site [a]			
Bar soap	55	91.7	(81.1, 96.6)
Detergent	3	5.0	(1.6, 14.8)
Liquid soap	6	10.0	(4.5, 20.9)
Ash / mud / sand	0	0.0	-
Any soap in household for handwashing [b]	178	73.6	(67.6, 78.8)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Data available only if handwashing place observed.

[d] Soap in households includes soap at handwashing site or soap shown by respondent, and includes bar soap, detergent and liquid soap.

7.2 Knowledge, attitude and practice regarding biofortified beans and OSFP

Table 25. Household knowledge, attitude and practice regarding beans

Characteristic	n	%[a]	(95% CI)[b]
Household has ever heard of biofortified beans			
No	81	36.3	(30.2, 42.9)
Yes	142	63.7	(57.1, 69.8)
Where households have heard of biofortified beans			
Village/ community meetings	55	34.6	(27.5, 42.4)
Relatives/ friends/ neighbors	45	28.3	(21.8, 35.9)
Health extension workers	10	6.3	(3.4, 11.4)
Community leaders	13	8.2	(4.8, 13.6)
Women groups	1	0.6	(0.1, 4.4)
Market place/ shop	11	6.9	(3.8, 12.1)
What households like about biofortified beans			
Are good for iron status	33	20.8	(15.1, 27.8)
Protect against anemia	11	6.9	(3.8, 12.1)
Are good for health	67	42.1	(34.6, 50.0)
Good for development	0	0.0	-
Taste	89	56.0	(48.1, 63.6)
Texture	35	22.0	(16.2, 29.2)
Physical characteristics (color, shape)	15	9.4	(5.7, 15.1)
Short cooking time	12	7.5	(4.3, 12.9)
Storage superiority	0	0.0	-
Price	4	2.5	(0.9, 6.6)
Crop yield	36	22.6	(16.7, 29.9)
What households do not like about biofortified beans			
Don´t trust them	1	0.6	(0.1, 4.4)
Not good for health	0	0.0	-
Texture	1	0.6	(0.1, 4.4)
Taste	2	1.3	(0.3, 5.0)
Physical characteristics (size, shape, color)	1	0.6	(0.1, 4.4)
Long cooking time	0	0.0	-
Household knows where to buy biofortified beans			
No	102	64.2	(56.3, 71.3)
Yes	57	35.8	(28.7, 43.7)
Where to buy biofortified beans			
Shop	14	24.6	(14.9, 37.7)
Farmer	17	29.8	(19.1, 43.3)
Market/street stand	43	75.4	(62.3, 85.1)
Moving street vendor	2	3.5	(0.8, 13.5)
Household has ever bought biofortified beans			
No	122	76.7	(69.5, 82.7)
Yes	37	23.3	(17.3, 30.5)

Table continued on next page

Characteristic	n	%[a]	(95% CI)[b]
Place household has ever bought biofortified beans			
Shop	8	21.6	(10.8, 38.5)
Farmer	10	27.0	(14.7, 44.2)
Market/street stand	24	64.9	(47.6, 78.9)
Moving street vendor	1	2.7	(0.3, 18.3)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 26. Household knowledge, attitude and practice regarding OFSP

Characteristic	n	%[a]	(95% CI)[b]
Household has ever heard of OFSP			
No	115	50.4	(43.9, 56.9)
Yes	113	49.6	(43.1, 56.1)
Where households have heard of OFSP			
Village/ community meetings	34	28.8	(21.3, 37.7)
Relatives/ friends/ neighbors	27	22.9	(16.1, 31.5)
Health extension workers	23	19.5	(13.2, 27.8)
Community leaders	9	7.6	(4.0, 14.1)
Women groups	6	5.1	(2.3, 11.0)
Market place/ shop	21	17.8	(11.8, 25.9)
What households like about OFSP			
Are good for vitamin A status	39	33.1	(25.1, 42.1)
Are good for the eyes	22	18.6	(12.5, 26.8)
Are good for brain development	5	4.2	(1.8, 9.9)
Good for health	26	22.0	(15.4, 30.5)
Good for development	3	2.5	(0.8, 7.7)
Taste	55	46.6	(37.7, 55.8)
Texture	4	3.4	(1.3, 8.8)
What households do not like about OFSP			
Don´t trust them	5	4.2	(1.8, 9.9)
Not good for health	0	0.0	-
Texture	5	4.2	(1.8, 9.9)
Taste	13	11.0	(6.5, 18.2)
Color	2	1.7	(0.4, 6.6
Quality	1	0.8	(0.1, 5.9)
Price	6	5.1	(2.3, 11.0)
Crop yield	7	5.9	(2.8, 12.0)
Household knows where to buy OFSP			
No	92	78.0	(69.5, 84.6)
Yes	26	22.0	(15.4, 30.5)
Where to buy OFSP			
Shop	0	0.0	-
Farmer	11	42.3	(24.2, 62.8)
Market/street stand	19	73.1	(51.7, 87.3)
Moving street vendor	0	0.0	-
Household has ever bought OFSP			
No	93	78.8	(70.4, 85.3)
Yes	25	21.2	(14.7, 29.6)
Place household has ever bought OFSP			
Shop	0	0.0	-
Farmer	8	32.0	(16.0, 53.7)
Market/street stand	16	64.0	(42.5, 81.0)
Moving street vendor	0	0.0	-

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

7.3 Seasonality of crop purchase

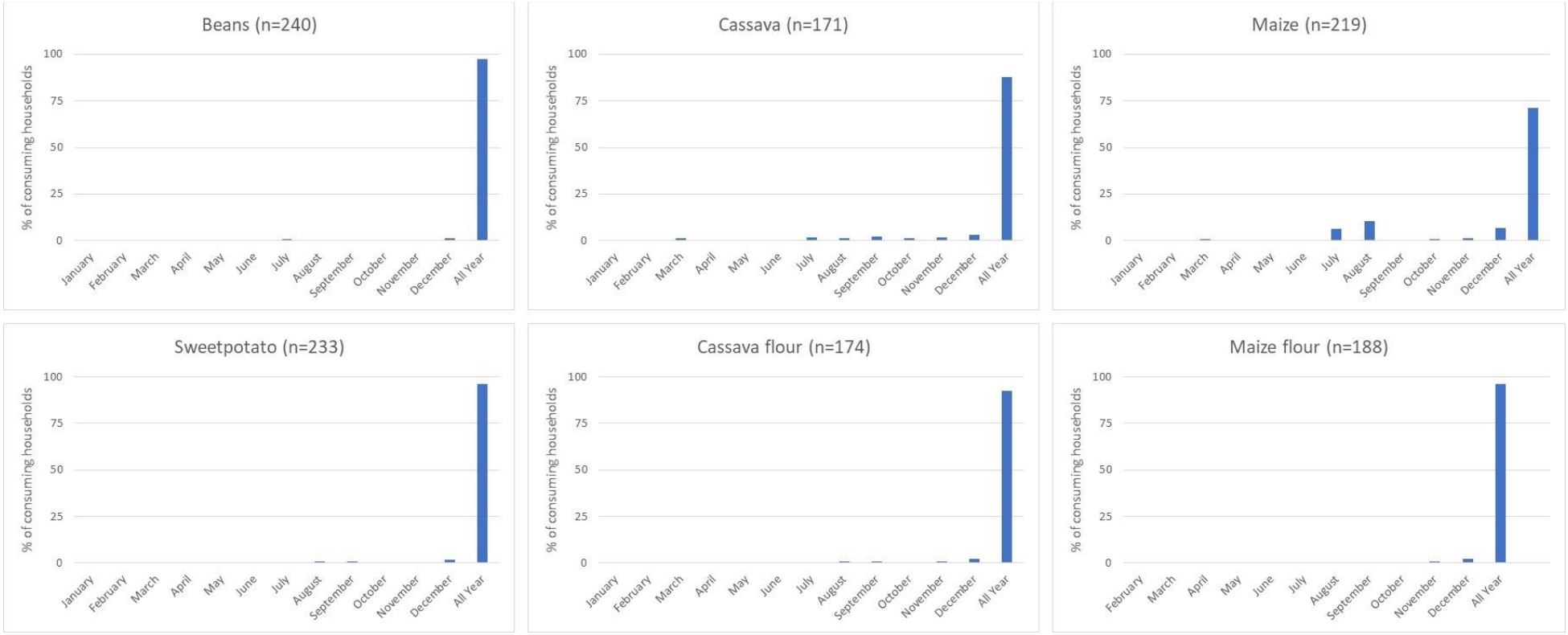

Figure 11. Seasonality of household biofortifiable crop purchase

7.4 Crop processing methods

Table 27. Bean processing methods

Characteristic	n	%[a]	(95% CI)[b]
Household soaks beans before cooking			
No	196	81.7	(76.2, 86.1)
Yes	44	18.3	(13.9, 23.8)
Household replaces soaking water before cooking[c]			
No	5	11.4	(4.6, 25.3)
Yes	39	88.6	(74.7, 95.4)
Households consumes cooking water			
No	33	13.8	(9.9, 18.8)
Yes	207	86.3	(81.2, 90.1)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

[c] Question only asked if respondent responded that household typically soaked beans before cooking

Table 28. Sweet potatoes processing methods

Characteristic	n	%[a]	(95% CI)[b]
Household preparation methods for sweet potato roots			
Boiling	233	100.0	-
Steam	0	0	-
Frying	33	14.2	(10.2, 19.3)
Roasting	67	28.8	(23.3, 34.9)
Baking	2	0.9	(0.2, 3.4)
Household produces flour/ dried pieces from fresh sweet potatoes			
No	228	97.9	(94.9, 99.1)
Yes	5	2.1	(0.9, 5.1)
Household fresh root drying method			
In the sun	5	100.0	-
In the shade	0	0.0	-
In the oven	0	0.0	-

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 29. Cassava processing method

Characteristic	n	%[a]	(95% CI)[b]
Household preparation methods for cassava			
Boiling	171	100.0	-
Roast	4	2.3	(0.9, 6.1)
Fermenting	1	0.6	(0.1, 4.1)
Household produces flour/ dried pieces from fresh cassava			
No	154	90.1	(84.5, 93.8)
Yes	17	9.9	(6.2, 15.5)
Household fresh root drying method			
In the sun	17	100.0	-
Household buys cassava flour			
No	67	27.7	(22.4, 33.7)
Yes	175	72.3	(66.3, 77.6)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

Table 30. Maize processing method

Characteristic	n	%[a]	(95% CI)[b]
Household preparation methods for maize cobs			
Boiling	194	88.6	(83.6, 92.2)
Steam	0	0.0	-
Baking	30	13.7	(9.7, 19.0)
Household produces flour/ dried pieces from maize cobs			
No	122	55.7	(49.0, 62.2)
Yes	97	44.3	(37.8, 51.0)
Household maize cob drying method			
In the sun	85	87.6	(79.3, 92.9)
In the shade	12	12.4	(7.1, 20.7)
Household buys maize flour			
No	54	22.3	(17.5, 28.0)
Yes	188	77.7	(72.0, 82.5)

Note: The n's are un-weighted numbers for each subgroup; subgroups that do not sum to the total have missing data

[a] Percentages unweighted to account for equal probability of selection.

[b] CI=confidence interval, calculated taking into account the simple random sampling design.

8 APPENDICES

8.1 LIST OF SELECTED VILLAGES

No	District (Akarere)	Sector (Umurenge)	Cell (Akagali)	Village (Umudugudu)	Location
1	Musanze	Busogo	Nyagisozi	Kirezi	Rural
2	Musanze	Cyuve	Kabeza	Bucuzi	Rural
3	Musanze	Cyuve	Migeshi	Nyaruyaga	Rural
4	Musanze	Cyuve	Rwebeya	Nganzo	Peri urban
5	Musanze	Gacaca	Kabirizi	Mukungwa	Rural
6	Musanze	Gashaki	Kigabiro	Musekera	Rural
7	Musanze	Gataraga	Rubindi	Gacondo	Rural
8	Musanze	Gataraga	Rubindi	Gataraga	Rural
9	Musanze	Kimonyi	Kivumu	Nyamugari	Rural
10	Musanze	Muko	Cyivugiza	Susa	Rural
11	Musanze	Musanze	Cyabagarura	Kanyabirayi	Rural
12	Musanze	Nkotsi	Bikara	Kiruhura	Rural
13	Musanze	Nkotsi	Bikara	Nyakinama	Rural
14	Musanze	Nyange	Kabeza	Ntamiziro	Rural
15	Musanze	Nyange	Kamwumba	Ntarama	Rural
16	Musanze	Nyange	Muhabura	Nkogote	Rural
17	Musanze	Nyange	Ninda	Garuka	Rural
18	Musanze	Remera	Rurambo	Gatare	Rural
19	Musanze	Remera	Rurambo	Kabusozo	Rural
20	Musanze	Remera	Rurambo	Mugeshi	Rural
21	Musanze	Shingiro	Mudende	Vubiro	Rural
22	Musanze	Muhoza	Cyabararika	Bwuzuri	Peri Urban
23	Musanze	Muhoza	Cyabararika	Buhuye	Peri Urban
24	Musanze	Muhoza	Cyabararika	Gasanze	Peri Urban
25	Musanze	Muhoza	Cyabararika	Kabogobogo	Peri Urban

8.2 ETHICAL APPROVAL

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 19th/07/2019

Dr. Nicolai Petry
GroundWork
Gotthardstrasse 47, 8800 Thalwil
Switzerland

Approval Notice: No 367/CMHS IRB/2019

Your Project entitled ***"Assessing the Coverage of Biofortified Crops in Rwanda"*** has been evaluated by CMHS Institutional Review Board.

Name of Members	Institute	Involved in the decision		
		Yes	No (Reason)	
			Absent	Withdrawn from the proceeding
Prof Kato J. Njunwa	UR-CMHS	X		
Prof Jean Bosco Gahutu	UR-CMHS			X
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS		X	
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting where the quorum was met and revisions made on the advice of the CMHS IRB submitted on 19th July 2019, **Approval has been granted to your study.**
Please note that approval of the protocol and consent form is valid for **12 months**.

Email: researchcenter@ur.ac.rw P.O Box 3286 Kigali, Rwanda www.ur.ac.rw

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 19th July 2019

Expiration date: The 19th July 2020

Professor Kato Njunwa
For the Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

Email: researchcenter@ur.ac.rw P.O Box 3286 Kigali, Rwanda www.ur.ac.rw

8.3 INFORMATION SHEET AND CONSENT FORM

Title of Study:	**Assessing the Coverage of Biofortified Crops in Rwanda**
Principal Investigators:	Dr. Nicolai Petry, GroundWork, Switzerland Dr. James Peter Wirth, GroundWork, Switzerland
Certified Protocol Number:	367/CMHS IRB/2019

INFORMATION SHEET AND WRITTEN CONSENT TO PARTICIPATE IN RESEARCH

General Information about Research

Micronutrient deficiencies are a major public health problem affecting many people in the world. Iron, vitamin A, iodine and zinc deficiencies are among the world's most serious risk factors for health and development. Biofortification, the development of crops such as beans and orange fleshed sweet potatoes, with high concentration of nutrients, is a promising approach to reduce micronutrient deficiencies. To assess the successful implementation of biofortification programs, information on the household-level coverage and consumption of biofortified foods is necessary. The goal of the study is to test a newly-developed questionnaire, which collects information on household coverage of biofortified crops. We want to better understand the household acceptability, purchase and consumption of biofortified crops as well as cooking methods and storage conditions. Therefore, we will ask questions about your household and your food habits.

For the study, we will include about 200 households in the district. Today, you are invited to respond to questions, which will take about 45 minutes of your time. You have been asked to take part in this study because your household was randomly selected.

If you decide to participate in the survey, you will stay about 45 minutes with me to give the important information needed for the study. I will ask you questions about your household, about biofortification in general, about beans, orange fleshed sweet potatoes, cassava and maize.

Benefits/Risk of the study

There is no risk for you to participate in the study; I will ask you questions; again, if you don't feel comfortable giving an answer to one question, please let me know.

We cannot promise the study will help you directly but the information we get from the study will help to make biofortification programs more successful, helping to reduce micronutrient deficiencies in Rwanda and other African countries.

Confidentiality

All information which is collected about you and your household during the course of the interview will be kept strictly confidential and the household address will not be included in the final report so that you cannot be recognized.

Only the personnel doing the interview and the principal researchers will have access to identifiable information.

Compensation

Your participation in this interview is important and we do appreciate the time made available.

Withdrawal from Study

Your participation in this survey is fully voluntarily and you can withdraw from participation at any time, even after you agreed to participate. It is important for you to understand that at any point during the interview, you can just tell me and I will stop with the interview. There will not be any negative effects on you, if you decide that you no longer want to continue with the interview.

In a moment, I will ask you to give written consent to take part in the survey. This information sheet will be for you/your caretaker to keep. If you have any question, do not hesitate to contact the principal researchers.

Contact for Additional Information

If you would like to get further information about this study please feel free to contact Mr. Arcade Nkundineza (*mobile phone number**) or Prof. Dr. Jean Bosco Gahutu (*mobile phone number**).

This study has been approved by the University of Rwanda Institutional Review Board (permit number 367/CMHS IRB/2019). If you have concerns or complaints about the conduct of this study, please contact a member the University of Rwanda Institutional Review Board (phone +250 783 340 040).

_____

Name of household head or adult respondent

_____

_____

Signature or mark of household head or adult respondent **Date (dd/mm/yy)**

*Mobile phone numbers removed for report version of information sheet and consent form

8.4 TEAMS, TEAM LEADERS, AND INTERVIERWERS

Team 1			
No	**ID**	**Gentil Mbonyinshuti**	**Team leader**
1	RW172	Christophile Nshimiyimana	Interviewer
2	RW176	Maombi Pacis Iradukunda	Interviewer
3	RW179	Desire Nduwumwami	Interviewer
4	RW180	Samuel Mushimiyimana	Interviewer
5	RW175	Catherine Nyirankunzabo	Interviewer

Team 2			
No	**ID**	**Vivens Niyondora**	**Team leader**
1	RW169	Janvier Niyibigize	Interviewer
2	RW177	Emma Claudine Mutuyemariya	Interviewer
3	RW139	Everygiste Tuwamine	Interviewer
4	RW185	Andromaque Iyamubonye	Interviewer
5	RW174	Marthe Nyiraguhirwa	Interviewer

8.5 MARKET VISIT QUESTIONNAIRE

RWANDA BIOFORTIFIED FOODS COVERAGE SURVEY 2019 MARKET VISIT QUESTIONNAIRE					
Question pattern	Question Type	Question ID	Question	*Hint/**instructions for programmer***	Options & Skips
Instructions for interviewer: When entering the market, please visit all vendors selling beans and sweet potatoes. Each vendor of beans and sweet potatoes should be interviewed separately; do NOT conduct group interviews with the vendors. **Prior to starting interviews, please record the following information on a piece of paper, as this information will need to be entered for all interviews conducted in this market:** **-District** **-Village name** **-Name of the market**					
Market information (MI)					
Autofilled	Date		Date of interview		
Autofilled	Time		Start time		
	Name	MI1	District		
	Name	MI2	Village/ community name		
	Name	MI3	Name of market	*If the market has no name enter "no name"*	
	Geopoint	MI4	Record your location:	*You need to be outside to record the location. If the accuracy is less or equal to 12 meter, you can save the location. Do not forget to SWITCH ON YOUR GPS and switch off afterwards.*	
Market vendor (MV)					
Autofilled	Number	MV1	Market vendor number	*Fill in sequential number. If more than 2 interviewers, interviewer 1 should take numbers 01-10 and interviewer 2 numbers 06-20*	
	Single Choice	MV2	Hello, my name is (NAME) and I am working for Sagaci Research, a market research firm. We are conducting a survey of sellers of beans and sweet potatoes in Rwanda. Would you be available for a short interview (about 5 min) about some of the crops you sell?		1=Yes 2=No (**skip to FR1**)

			The results of the interview will be used for a future household survey conducted in the district. No identifying information will be collected. Oral consent provided?		
Market vendor beans (B)					
	Single choice	B1	**Do you sell beans for eating?**	*Select "no" if the vendor only sells beans used for planting*	1=Yes 2=No **(skip to S1)**
	Multiple choice	B2	**What are the typical units of measure you use to sell beans?**		
		B2a	Grams		1=Yes 2=No
		B2b	Kilograms		1=Yes 2=No
		B2c	Bags		1=Yes 2=No
		B2d	Cans		1=Yes 2=No
		B2e	Other		1=Yes 2=No (**skip to B3**)
	Text		Type in the "other option"		
	Single choice	B3	**Where do you get the beans for eating from?**		1= I grow them myself 2= Directly from a farmer 3= From a retailer 4= From a local market 5= From a Supermarket 8= Other
		B3_other	Type in "other option"		
	Single choice	B4	**Do you sell different bean varieties for eating?**		1=Yes 2=No
	Single choice	B5	**Do you also sell beans high in iron?**		1= Yes, exclusively **(skip to B7)** 2= Yes, some of the bean varieties I sell are high in iron **(skip to B7)** 3= No 9= Don´t know
	Multiple choice	B6	**Why don´t you sell high iron beans?**	**After this question skip to skip to S1** *Do not prompt*	
		B6a	Never heard of them		1=Yes 2=No
		B6b	Not easily available		1=Yes 2=No
		B6c	Don´t like them		1=Yes 2=No
		B6d	They don´t sell well/ no demand		1=Yes 2=No
		B6e	Too expensive		1=Yes

					2=No
		B6f	Not good for health		1=Yes 2=No
		B6g	No good yield		1=Yes 2=No
		B6h	Don´t know		1=Yes 2=No
		B6i	Other		1=Yes 2=No
	Text	B6i_other	Type the “other” option		
	Multiple choice	B7	**How do you know these beans are high in iron?**	**Only ask if B3=1** *Do not prompt*	
		B7a	Received or bought certified high-iron bean seeds for breeding		1=Yes 2=No
		B7b	Was told by the person from whom I bought the bean seeds for breeding		1=Yes 2=No
		B7c	Physical characteristic (shape, color, size)		1=Yes 2=No
		B7d	Other (specify)		1=Yes 2=No
	Text	B7d_other	Type the “other” option		
	Multiple choice	B8	**How do you know these beans are high in iron?**	**Only ask if B3≠1** *Do not prompt*	
		B8a	The beans I sell for consumption are certified high-iron beans		1=Yes 2=No
		B8b	Was told by the person from whom I bought the beans		1=Yes 2=No
		B8c	Physical characteristic (shape, color, size)		1=Yes 2=No
		B8d	Other (specify)		1=Yes 2=No
	Text	B8d_other	Type the “other” option		
		B9	**Do you know the advantages of high iron beans?**	*Do not prompt*	
		B9a	High in iron		1=Yes 2=No
		B9b	Are good for health		1=Yes 2=No
		B9c	Better quality		1=Yes 2=No
		B9d	Better taste		1=Yes 2=No
		B9e	Better price		1=Yes 2=No
		B9f	Higher yield		1=Yes 2=No
		B9g	Don´t know		1=Yes 2=No
		B9h	Other (specify)		1=Yes 2=No

		B9h_other	Type the "other" option		
	Single choice	B10	**Do you think your clients know which beans are high in iron?**		1=Yes 2=No
	Single choice	B11	**Do you usually inform customers which of the bean varieties are high iron beans?**		1=Yes 2=No
	Single choice	B12	**Do you usually promote high iron beans over normal beans?**		1=Yes 2=No
	Single choice	B13	**Is it possible for the customer to distinguish between high iron and normal iron beans by outward appearance of beans?**		1=Yes 2=No (**skip to B15)**
	Text	B14	**How?**		
	Single choice	B15	**Do you know any specific words or terms for high-iron beans in Kinyarwanda?**		1=Yes 2=No (**skip to S1**)
	Text	B15a	**How are high-iron beans called in Kinyarwanda?**		
Market vendor sweet potatoes (S)					
	Single choice	S1	**Do you sell sweet potato roots or products made from sweet potato roots?**		1=Yes 2=No (**skip to FR**)
	Multiple choice	S2	**What are the typical weight units of measure for sweetpotato roots?**		
		S2a	Grams		1=Yes 2=No
		S2b	Kilograms		1=Yes 2=No
		S2c	Bags		1=Yes 2=No
		S2d	Cans		1=Yes 2=No
		S2e	Other		1=Yes 2=No (**skip to S3**)
	Text		Type in the "other option"		
	Multiple choice	S3	**In which form do you sell sweet potato roots?**		
		S3a	Fresh roots		1=Yes 2=No
		S3b	Dried chips		1=Yes 2=No
		S3c	Flour		1=Yes 2=No
		S3d	Other		1=Yes 2=No
	Text	S3d_other	Type in the "other option"		
	Single choice	S4	**What varieties of sweet potato roots do you sell?**		1= Orange fleshed only (**skip to S6**) 2= White fleshed only

					3= Both white and orange fleshed (**skip to S6)** 9= Don´t know
		S5	**Why don´t you sell orange fleshed sweet potatoes?**	*Show picture of orange sweet potatoes if the vendor does not know what it is.* *Do not prompt*	
		S5a	Never heard of them		1=Yes 2=No
		S5b	Not easily available		1=Yes 2=No
		S5c	Don´t like them		1=Yes 2=No
		S5d	They don´t sell well/ no demand		1=Yes 2=No
		S5e	Too expensive		1=Yes 2=No
		S5f	Don´t know		1=Yes 2=No
		S5g	Not good for health		1=Yes 2=No
		S5h	No good yield		1=Yes 2=No
		S5i	Other		1=Yes 2=No
	Text	S5i_other	Type in the “other option”		
	Multiple choice	S6	**Do you know the advantage of orange fleshed sweet potatoes?**	*Do not prompt*	
		S6a	Contain pro-vitamin A		1=Yes 2=No
		S6b	Are good for health		1=Yes 2=No
		S6c	Better quality		1=Yes 2=No
		S6d	Better taste		1=Yes 2=No
		S6e	Better price		1=Yes 2=No
		S6f	Higher yield		1=Yes 2=No
		S6g	Don´t know		1=Yes 2=No
		S6h	Other (specify)		1=Yes 2=No
	Text	S6h_other	Type the “other” option		
	Single choice	S7	**Do you usually inform your customers about the advantages of orange fleshed sweet potatoes?**	**skip if S4=2 or 9**	1=Yes 2=No
	Single choice	S8	**Do you usually promote orange fleshed sweet**	**skip if S4=2 or 9**	1=Yes 2=No

			potatoes over white fleshed sweet potatoes?		
	Single choice	S9	**Do you know any specific words or terms for orange fleshed sweet potato in Kinyarwanda?**		1=Yes 2=No (**skip to FR1**)
	Text	S9a	**How are orange fleshed sweetpotatoes called in Kinyarwanda?**	*Record all the terms the respondent says. Separate terms with semicolon (;)*	
Final result					
	Single choice	FR1	**Final result**		1=Interview successfully completed 2=Vendor refused participation

8.6 COVERAGE SURVEY QUESTIONNAIRE

RWANDA BIOFORTIFIED FOODS COVERAGE STUDY 2019 HOUSEHOLD QUESTIONNAIRE					
Question pattern	**Question Type**	**Question ID**	**Question**	***Hint/instructions for programmer***	**Options & Skips**
Household Information (HI)					
	Integer	HI1	Team number		1= Team 1 2= Team 2 3= Team 3
	Text	HI2	Interviewer name	***Enter your name***	1=Interviewer number …
Autofilled	Date		Date of interview		
Autofilled	Time		Start time		
	Name	HI3	District		
	Integer	HI4	Cluster number	***Should allow to enter numbers 1 -25;*** *Take this information from the cluster control form*	
	Integer	HI5	HH number from cluster control form	***Should be from 1-40;*** *Take this information from the cluster control form*	
	Text	HI6	**What is the name of the head of household?**		
	Single choice	HI7	**Written permission given to proceed with household interview?**	*Written informed consent can be obtained from any eligible household member, not necessarily the household head*	1=Yes 2=No **(Skip to FR1)**
Demographics (DG)					
First, I would like to ask you some general questions about the people who permanently lived in this household in the past 30 days.					

A household is defined as "A group of individuals, with family or other social relations among themselves, eating from the same pot and sharing common resources".

Please tell me the name of each person who usually lives here, starting with the head of the household. List the head of the household in line 01.

List all household members and their sex. Then ask: **Are there any others who live here, even if they are not at home now?**

Household Roster

DG1	DG2	DG3		DG4		DG5	DG6		DG7
Line No (autofilled)	Name of household member?	Is (Name) male or female?		What is (name)'s date of birth? 99 DK 9999 DK		(Name) IS X YEARS OLD? *(Autocalculated assuming Day of birth = 15)* *If this age is not correct, please go back and fix birthdate* 99 DK	Woman pregnant? **Skip if DG3=1 Skip if <12y or >55y**		Who is the mother or primary caretaker of this child? **Skip if DG5>5.0 years** *Record line no. of mother or caregiver*
Line	Name	M	F	Month	Year	Age	Yes	No	caregiver
01	Household Head	1	2	__ __	__ __ __ __	__ __	1	2	__ __
02		1	2	__ __	__ __ __ __	__ __	1	2	__ __
03		1	2	__ __	__ __ __ __	__ __	1	2	__ __
04		1	2	__ __	__ __ __ __	__ __	1	2	__ __
05		1	2	__ __	__ __ __ __	__ __	1	2	__ __
06		1	2	__ __	__ __ __ __	__ __	1	2	__ __
07		1	2	__ __	__ __ __ __	__ __	1	2	__ __
08		1	2	__ __	__ __ __ __	__ __	1	2	__ __
09		1	2	__ __	__ __ __ __	__ __	1	2	__ __
10		1	2	__ __	__ __ __ __	__ __	1	2	__ __
11		1	2	__ __	__ __ __ __	__ __	1	2	__ __
12		1	2	__ __	__ __ __ __	__ __	1	2	__ __
13		1	2	__ __	__ __ __ __	__ __	1	2	__ __
14		1	2	__ __	__ __ __ __	__ __	1	2	__ __
15		1	2	__ __	__ __ __ __	__ __	1	2	__ __
16		1	2	__ __	__ __ __ __	__ __	1	2	__ __

17		1 2	__ __	__ __ __ __	__ __	1 2	__ __
18		1 2	__ __	__ __ __ __	__ __	1 2	__ __
19		1 2	__ __	__ __ __ __	__ __	1 2	__ __
20		1 2	__ __	__ __ __ __	__ __	1 2	__ __

Probe for additional household members. Probe especially for any infants or small children not listed, and others who may not be members of the family (such as servants, friends) but who usually live in the household. Insert names of additional members in the household list and complete form accordingly.

Household characteristics (HHC)					
	Single choice	HHC1	Type of housing unit	*Record observation*	1=Apartment 2=Hut 3=House **(if 1, 2, or 3, skip to HHC2)** 8=Other (specify)
	Text	HHC1other	Type the "other" option		
	Integer	HHC2	**How many rooms in this house/apartment are used for sleeping?**		
	Single Choice	HHC3	Main material of the dwelling floor	*Record observation*	Natural floor 11= Earth / Sand 12= Dung Rudimentary floor 21= Wood planks 22= Palm/Bamboo Finished floor 31= Parquet or polished wood 32= Vinyl or asphalt strips 33= Ceramic tiles 34= Cement 35= Carpet **(skip to HHC 4)** 88= Other (specify)
	Text	HHC3other	Type the "other" option		
	Single Choice	HHC4	Main material of the roof	*Record observation*	Natural roofing 11= No Roof 12= Thatch / Palm leaf/ Leaf Rudimentary Roofing 21= Rustic mat/Plastic 22= Palm / Bamboo 23= Wood planks 24= Cardboard Finished roofing

					31= Metal/Iron sheet 32= Wood 33= Calamine / Cement fibre 34= Ceramic tiles 35= Cement 36= Roofing shingles 37= Clay tiles **(skip to HHC5)** 88 = Other (specify)
	Text	HHC4other	Type the "other" option		
	Single Choice	HHC5	Main material of the exterior walls	*Record observation*	Natural walls 11= No walls 12= Cane / Palm / Trunks 13= Dirt/ mud Rudimentary walls 21= Bamboo with mud 22= Stone with mud 23= Uncovered adobe 24= Plywood 25= Cardboard 26= Reused wood Finished walls 31= Cement 32= Stone with lime / cement 33= Bricks 34= Cement blocks 35= Covered adobe 36= Wood planks / shingles 37= Wood with mud **(skip to HHC6)** 88= Other (specify)
	Text	HHC5other	Type the "other" option		
	Single Choice	HHC6	**What type of fuel does your household mainly use for cooking?**	*Only one answer*	1= Electricity 2= Liquefied Petroleum Gas (LPG) 3= Natural gas 4= Biogas 5= Kerosene 7= Charcoal 8= Wood 9= Straw / shrubs / grass 10= Agricultural crop 11= Animal dung 77= No food cooked in household

					99= Don't know **(skip to HHC7)** 88= Other (specify)
	Text	HHC6other	Type the "other" option		
	Single choice	HHC7	**Is your house connected with electricity**		1=Yes 2=No
	Multiple Choice	HHC8	**Does your household have?**	*Ask about each item separately*	
		HHC8a	Radio/tape recorder		1=Yes 2=No
		HHC8b	Television		1=Yes 2=No
		HHC8c	Satellite		1=Yes 2=No
		HHC8d	Land telephone		1=Yes 2=No
		HHC8e	Refrigerator		1=Yes 2=No
		HHC8f	Freezer		1=Yes 2=No
		HHC8g	Washing machine		1=Yes 2=No
		HHC8h	Dish washer		1=Yes 2=No
		HHC8i	Solar panel		1=Yes 2=No
		HHC8j	Air conditioner		1=Yes 2=No
		HHC8k	Fan		1=Yes 2=No
		HHC8l	Water cooler		1=Yes 2=No
		HHC8m	Microwave		1=Yes 2=No
		HHC8n	Digital camera		1=Yes 2=No
		HHC8o_1	Personal computer or tablet		1=Yes 2=No**(Skip to HHC8p)**
	Integer	HHC8o_2	How many personal computers or tablets do you have in total in your household?	*Enter number of devices*	

		HHC8p_1	Mobile phone		1=Yes 2=No**(Skip to HHC8q)**
	Integer	HHC8p_2	How many mobile phones do you have in total in your household?	*Enter number of devices*	
		HHC8q	Internet subscription on mobile phone		1=Yes 2=No
	Single Choice	HHC9	**Do you or someone living in this household own this dwelling?**	*I If "No", then ask: Do you rent this dwelling from someone not living in this household?* *If "Rented from someone else", select "2". For other responses, select "8".*	1=Own 2=Rent 8=Other (specify) 9=Don't know
	Text	HHC9other	Type the "other" option		
Water, Sanitation and Hygiene (WASH)					
	Single Choice	WASH1	**What is the <u>main</u> source of <u>drinking water</u> for the members of your household?**	*Only one answer*	Piped water 11= Piped into dwelling 12= Piped into compound, yard or plot 14= Public tap / standpipe 21= Tube well or borehole Dug well 31= Protected well 32= Unprotected well Water from spring 41= Protected spring 42= Unprotected spring 51= Rainwater collection 61= Tanker-truck 71= Cart with small tank or drum 81= Surface water (river, stream, dam, lake, pond, canal, irrigation channel) 91= Bottled water 92= Sachet water 99= Don't know **<u>(skip to WASH2)</u>** 88= Other (specify)

	Text	WASH1_ other	Type the "other" option		
	Single Choice	WASH2	**Do you do anything at home to the water to make it safer to drink?**		1=Yes 2=No (**skip to WASH4)** 9= Don´t know(**skip to WASH4)**
	Multiple Choice	WASH3	**What do you usually do to make the water safer to drink?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
		WASH3a	Boil		1=Yes 2=No
		WASH3b	Add bleach or chlorine (liquid or tablets)		1=Yes 2=No
		WASH3c	Strain it through a cloth		1=Yes 2=No
		WASH3d	Use a water filter (ceramic, sand, composite, etc.)		1=Yes 2=No
		WASH3e	Solar disinfection		1=Yes 2=No
		WASH3f	Let it stand and settle		1=Yes 2=No
		WASH3g	Purification tablet		1=Yes 2=No
		WASH3h	Don't know		1=Yes 2=No
		WASH3e	Other (specify)		1=Yes 2=No (**skip to WASH4**)
	Text	WASH3e _other	Type the "other" option		
	Single Choice	WASH4	**What kind of toilet facility do members of your household usually use?**	*Do not prompt.* *If "flush", probe: Where does it flush to?*	Flush/ Pour flush 11= Flush to piped sewer system 12= Flush to septic tank 13= Flush to pit latrine 14= Flush to somewhere else Pit latrine 21= Ventilated improved pit latrine 22= Pit latrine with slab 23= Pit latrine without slab /open pit 41= Bucket

					51= Hanging toilet, hanging latrine 61= No facilities / bush / field 99= Don't know **(Skip to WASH5)** 88= Other (specify)
	Text	WASH4other	Type the "other" option		
	Single Choice	WASH5	**Do you share this toilet facility with others who are not members of your household?**		1=Yes 2=No 9= Don´t know
	Single choice	WASH6	**Please show me where members of your household most often wash their hands.**		1= Observed 2= Not in dwelling / plot / yard **(Skip to WASH9)** 3= No permission to see **(Skip to WASH9)**
	Single choice	WASH7	Observe presence of running water at the specific place for handwashing. Verify by checking the tap/pump, basin, bucket, water container or similar objects for presence of water.		1= Water is available 2= Water is not available 3= Did not observe
	Multiple choice	WASH8	Record if soap or detergent is present at the specific place for handwashing. Select Yes for each type of soap seen.		**Skip to AC1 if any in WASH81, WASH82 or WASH83 is YES.**
		WASH8a	Bar soap		1=Yes 2=No
		WASH8b	Detergent (Powder / Liquid /Paste)		1=Yes 2=No
		WASH8c	Liquid soap		1=Yes 2=No
		WASH8d	Ash / Mud / Sand		1=Yes 2=No
		WASH8e	None		1=Yes 2=No
	Single choice	WASH9	**Do you have any soap or detergent (or other locally used cleansing**		1=Yes 2=No **(Skip to AC1)** 9= Don´t know **(Skip to AC1)**

			agent) in your household for washing hands?		
	Multiple choice	WASH10	**Can you please show it to me?**	*Select Yes for each type of soap seen*	
		WASH10a	Bar soap		1=Yes 2=No
		WASH10b	Detergent (Powder / Liquid /Paste)		1=Yes 2=No
		WASH10c	Liquid soap		1=Yes 2=No
		WASH10d	Ash / Mud / Sand		1=Yes 2=No
		WASH10e	None		1=Yes 2=No
Agriculture (AC)					
	Single choice	AC1	**Does any member of this household own any land that can be used for agriculture?**		1=Yes 2=No (**skip to AC3)**
	Single choice	AC2	**How much agricultural land do members of this household own?**	*Enter 99.9 if respondent does not know*	A. Hectares ☐☐.☐ B. Acres ☐☐.☐ C. Plots ☐☐.☐ D. Are ☐☐.☐
	Single choice	AC3	**Does this household own any livestock, herds, other farm animals, or poultry?**		1=Yes 2=No (**skip to KAPB1)**
	Multiple choice	AC4	**Does your household own any of the following animals?**	*If none, enter '00'*	
		AC4a_1	Cattle		1=Yes 2=No
	Number	AC4a_2	*Quantity*		
		AC4b_1	Milk cows or bulls		1=Yes 2=No
	Number	AC4b_2	*Quantity*		
		AC4c_1	Horses, donkeys, mules		1=Yes 2=No
	Number	AC4c_2	*Quantity*		
		AC4d_1	Goats		1=Yes 2=No

	Number	AC4d_2	*Quantity*		
		AC4e_1	Sheep		1=Yes 2=No
	Number	AC4e_2	*Quantity*		
		AC4f_1	Rabbits		1=Yes 2=No
	Number	AC4f_2	*Quantity*		
		AC4g_1	Pigs		1=Yes 2=No
	Number	AC4g_2	*Quantity*		
		AC4h_1	Chicken		1=Yes 2=No
	Number	AC4h_2	*Quantity*		
		AC4i_1	Other poultry		1=Yes 2=No
	Number	AC4i_2	*Quantity*		
		AC4j_1	Other (specify)		1=Yes 2=No
	Text	AC4j_1_ other	Type the "other option"		
	Number	AC4j_2	*Quantity*		
Beans (purchase, consumption, processing) (BNS)					
	Single choice	BNS1	**Does your household consume beans at home?**		1=Yes 2=No **(skip to (SP1)**
	Single choice	BNS2	**Does your household consume beans throughout the whole year?**		1=Yes (**skip to BNS4**) 2=No
	Multiple choice	BNS3	**During which months does your household consume beans in a typical year?**	*Select all months that apply*	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	BNS4	**The last time your household got beans for eating, where did you get them from?**	*This does not include seeds for cultivation*	1= Home grown 2= Local open market 3= Directly from farmer 4= Retail shop 5= Supermarket

					6= Food aid 7= Gift 9= Don´t know **(skip to BNS3)** 8= Other (specify)
	Text	BNS4_other	Type the "other" option		
	Single choice	BNS5	**The last time your household got beans for eating, what kind did you get?**	*This does not include seeds for cultivation*	1= High iron biofortified beans 2= Normal, traditional beans **(skip to BNS10)** 3= Both, high iron beans and normal, traditional beans 9= Don´t know **(skip to BNS10)**
	Multiple choice	BNS6	**How do you know these beans were high in iron?**	**(Only ask this question if BNS4=1 AND BNS5=1 OR BNS5=3)** *Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
		BNS6a	Received/ bought certified seeds		1=Yes 2=No **(skip to BNS8)**
		BNS6b	Was told by the one who gave/sold the seeds	**Skip to BNS8**	1=Yes 2=No
		BNS6c	Taste, texture	**Skip to BNS8**	1=Yes 2=No
		BNS6d	Appearance	**Skip to BNS8**	1=Yes 2=No
		BNS6e	Cooking characteristics	**Skip to BNS8**	1=Yes 2=No
		BNS6f	Growing characteristics	**Skip to BNS8**	1=Yes 2=No
		BNS6g	Yield	**Skip to BNS8**	1=Yes 2=No
		BNS6h	Don´t know	**Skip to BNS8**	1=Yes 2=No
		BNS6i	Other (specify)	**Skip to BNS8**	1=Yes 2=No
	Text	BNS6i_other	Type the "other" option	**Skip to BNS8**	
	Single choice	BNS7a	**Do you have the bag in which the high iron**	**Only if BNS6a=Yes**	1=Yes 2=No **(skip to BNS7c)**

			bean seeds were packed available?		
	Single choice	BNS7b	**Can I see it?**	**Only if BNS6a=Yes**	1=Yes 2=No **(skip to BNS7c)**
	Text	BNS7c	**Do you remember the name of the variety**	**Only if BNS6a=Yes** *Enter name of variety, also check bag to confirm* *If no name, enter "XXX"*	
	Single choice	BNS7d	**Take a picture of the beans and the bag if available**	*Take only one picture*	1=Yes 2=No
	Single choice	BNS7e	**May I have a small sample of the high iron beans?**	*Collect bean sample*	1=Yes 2=No **(Skip to BNS11)**
	Single choice	BNS7f	Bean sample collected and household number applied?		1=Yes 2=No **(Skip to BNS11)**
	Integer	BNS7g	Record ID number applied to sample	*Enter HH ID number starting with H*	**(Skip to BNS11)**
	Single choice	BNS8	**Do you remember the name of the variety**		1=Yes 2=No **(skip to BNS8b)**
	Text	BNS8a	**Enter name of variety**		
		BNS8b	**Take a picture of the high iron beans if available**	*Take only one picture*	
	Single choice	BNS8c	**May I have a small sample of the high iron beans?**	*Collect bean sample*	1=Yes 2=No **(Skip to BNS11)**
	Single choice	BNS8d	Bean sample collected and household number applied?		1=Yes 2=No **(Skip to BNS11)**
	Integer	BNS8e	Record ID number applied to sample	*Enter HH ID number starting with H*	**(Skip to BNS11)**
	Multiple choice	BNS9	**How do you know these beans are high in iron?**	**(Only ask this question if BNS4≠1 AND BNS5=1 OR BNS5=3)** *Do not prompt. Probe "Anything*	

				else?" *Record all responses mentioned*	
		BNS9a	Market vendor, seller		1=Yes 2=No
		BNS9b	Farmer		1=Yes 2=No
		BNS9c	Donor		1=Yes 2=No
		BNS9d	Appearance		1=Yes 2=No
		BNS9e	Cooking characteristics		1=Yes 2=No
		BNS9f	Don´t know		1=Yes 2=No
		BNS9g	Other (specify)		1=Yes 2=No
	Text	BNS9g_other	Type the "other" option		
	Single choice	BNS10	**Do you remember the name of the variety**		1=Yes 2=No **(skip to BNS10b)**
	Text	BNS10a	**Enter name of variety**		
		BNS10b	**Take a picture of the high iron beans if available**	*Take only one picture*	
	Single choice	BNS10c	**May I have a small sample of the high iron beans?**	*Collect bean sample*	1=Yes 2=No **(Skip to BNS11)**
	Single choice	BNS10d	Bean sample collected and household number applied?		1=Yes 2=No **(Skip to BNS11)**
	Integer	BNS10e	Record ID number applied to sample	*Enter HH ID number starting with H*	
		BNS11	**The last time your household got beans for eating, how much did you get?**	*If harvested, record total quantity from last harvest.* *If purchased, record total combined quantity for high-iron beans*	

				and traditional beans.	
	Single choice	BNS11a			1= Kilogram **(skip to BNS11d)** 2= Gram **(skip to BNS11d)** 3= Bag **(skip to BNS11c)** 4= Can 9= Don't know **(skip to BNS12)**
	Single choice	BNS11b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to BNS11d)** 8= Other
	Text	BNS11b_ other	Type in the "other" option		
	Single choice	BNS11c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to BNS11d)** 8= Other
	Text	BNS11c_ other	Type in the "other" option		
	Number	BNS11d	**How many?**	*Enter quantity*	
		BNS12	**How long does this amount usually last in your household?**		
	Single choice	BNS12a			1= days 2= weeks 3= months 4= don´t know **(skip to BNS13)**
	Number	BNS12b		*Enter number of days, weeks or months*	
	Number	BNS13	**The last time your household got beans for eating, what proportion was high iron beans (biofortified beans)?**	*Record the number of pebbles (out of the total 10) on the high iron (biofortified bean) pile*	

				(Only ask this question if BNS6=3)	
	Single choice	BNS13a	**How often does your household get beans?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to BNS14)**
	Number	BNS13b		*Enter number of days, weeks or months*	
	Single choice	BNS14	**Do you usually soak the beans before cooking?**		1=Yes 2=No **(skip to BNS15)**
	Single choice	BNS15	**Do you usually replace the soaking water with fresh water before cooking the beans?**		1=Yes 2=No
	Single choice	BNS16	**Do you usually consume the water in which the beans were cooked?**		1=Yes 2=No
Knowledge, attitude and practice biofortified beans (KAPBB)					
		KAPBB1	**Have you ever heard of high iron beans (biofortified beans)?**	*High iron bean = in Kinyarwanda* **Skip if BNS 5 is 1 or 3**	1=Yes 2=No **(skip to SP1)**
		KAPBB2	**Where did you hear the first time about high iron beans?**	*Do not prompt. Probe "Anything else?" Record all responses mentioned*	
		KAPBB2a	Village/ community meetings		1=Yes 2=No
		KAPBB2b	Relatives/ friends/ neighbors		1=Yes 2=No
		KAPBB2c	Health extension workers		1=Yes 2=No
		KAPBB2d	Community leaders		1=Yes 2=No
		KAPBB2e	Women groups		1=Yes 2=No
		KAPBB2f	Market place/ shop		1=Yes 2=No

		KAPBB2g	Rwanda Agricultural Board		1=Yes 2=No
		KAPBB2h	Seedling company		1=Yes 2=No
		KAPBB2i	TV		1=Yes 2=No
		KAPBB2j	Radio		1=Yes 2=No
		KAPBB2k	Billboards/wallpapers/ painted walls		1=Yes 2=No
		KAPBB2l	Other promotion activities		1=Yes 2=No
		KAPBB2m	Don't know		1=Yes 2=No
		KAPBB2n	Other (specify)		1=Yes 2=No (**skip to KAPBB3**)
		KAPBB2nother	Type the "other" option		
	Multiple choice	KAPBB3	**What do you like about high iron beans?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
		KAPBB3a	Are good for iron status		1=Yes 2=No
		KAPBB3b	Protect against anemia		1=Yes 2=No
		KAPBB3c	Are good for health		1=Yes 2=No
		KAPBB3d	Good for development		1=Yes 2=No
		KAPBB3e	Taste		1=Yes 2=No
		KAPBB3f	Texture		1=Yes 2=No
		KAPBB3g	Physical characteristics (size, shape, color)		1=Yes 2=No
		KAPBB3h	Short cooking time		1=Yes 2=No
		KAPBB3i	Storage superiority		1=Yes 2=No
		KAPBB3j	Price		1=Yes 2=No
		KAPBB3k	Crop yield		1=Yes 2=No

		KAPBB3l	Other (specify)		1=Yes 2=No (**skip to KAPBB4**)
	Text	KAPBB3l_other	Type the "other" option		
	Multiple choice	KAPBB4	**What do you NOT like about high iron beans?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
		KAPBB4a	Don´t trust them		1=Yes 2=No
		KAPBB4b	Not good for health		1=Yes 2=No
		KAPBB4c	Texture		1=Yes 2=No
		KAPBB4d	Taste		1=Yes 2=No
		KAPBB3e	Physical characteristics (size, shape, color)		1=Yes 2=No
		KAPBB4f	Long cooking time		1=Yes 2=No
		KAPBB4g	Storage inferiority		1=Yes 2=No
		KAPBB4h	Price		1=Yes 2=No
		KAPBB4i	Crop yield		1=Yes 2=No
		KAPBB4j	Other (specify)		1=Yes 2=No (**skip to KAPBB5**)
	Text	KAPBB4j_other	Type the "other" option		
	Single choice	KAPBB5	**Do you know where to buy/obtain biofortified beans for eating?**		1=Yes 2=No **(skip to KAPBB7)**
		KAPBB6	**Where can you buy or obtain biofortified beans for eating?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
			Shop		1=Yes 2=No
			Home grow biofortified beans		1=Yes 2=No

			Farmer		1=Yes 2=No
			Market/street stand		1=Yes 2=No
			Moving street vendor		1=Yes 2=No
			Other (specify)		1=Yes 2=No **(skip to KAPBB7)**
			Type the "other" option		
	Single choice	KAPBB7	**Have you ever bought/ grown/ received biofortified beans for eating?**		1=Yes 2=No (**skip to SP1)**
		KAPBB8	**Where did you buy or get biofortified beans for eating?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
			Shop		1=Yes 2=No
			Farmer		1=Yes 2=No
			Market/street stand		1=Yes 2=No
			Moving street vendor		1=Yes 2=No
			Other (specify)		1=Yes 2=No **(skip to SP1)**
			Type the "other" option		
Sweet potatoes (growing, purchase, consumption, processing) (SP)					
	Single choice	SP1	**Does your household eat sweet potatoes or prepare foods using fresh sweet potato roots (such as, chips) at home?**	*This does not include industrially produced sweet potato products. ONLY the fresh root*	1=Yes 2=No **(skip to CA1)**
	Single choice	SP2	**Does your household consume sweet potatoes or prepare products using fresh sweet potatoes (such as, chips) at home**		1=Yes (**skip to SP4**) 2=No

			throughout the whole year?		
	Number	SP3	**During which months does your household consume sweet potatoes or prepare products using fresh sweet potatoes (such as chips) in a typical year?**		1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	SP4	**The last time your household got fresh sweet potatoes, where did you get them from?**	*This does only include fresh roots and NOT industrialized products such as flour*	1= Home grown 2= Local open market 3= Directly from farmer 4= Retail shop 5= Supermarket 6= Food aid 7= Gift 9= Don´t know **(skip to SP5)** 8= Other (specify)
	Text	SP4_other	Type the “other” option		
	Single choice	SP5	**The last time your household got fresh sweet potatoes, what kind did you get?**		1= Orange fleshed 2= White fleshed 3= Both white and orange fleshed 9= Don´t know
	Number	SP6	**The last time your household got fresh sweet potatoes, how much did you get?**	*If harvested, record total quantity from last harvest.* *If purchased, record the total combined quantity for orange and white sweet potatoes.*	
	Single choice	SP6a			1= Kilogram **(skip to SP6d)** 2= Gram **(skip to SP6d)** 3= Bag **(skip to SP6c)** 4= Can 9= Don’t know **(skip to SP7)**

	Single choice	SP6b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to SP6d)** 8= Other
	Text		Type in the "other" option		**(skip to SP6d)**
	Single choice	SP6c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to SP6d)** 8= Other
	Text		Type in the "other" option		
	Number	SP6d	**How many?**	*Enter quantity*	
		SP7	**How long does this amount usually last in your household?**		
	Single choice	SP7a			1= days 2= weeks 3= months 4= don´t know **(skip to SP8)**
	Number	SP7b		*Enter number of days or weeks or months*	
	Number	SP8	**The last time your household got fresh sweet potatoes, what proportion was orange fleshed?**	*Record the number of pebbles (out of the total 10) on the orange fleshed sweet potato pile* **(Only ask this question if SP5=3)**	
	Single choice	SP9	**Do you have these sweet potatoes in your house or garden right now?**		1=Yes 2=No (**skip to SP9c**)
		SP9a	**May I see them?**		1=Yes

					2=No (**skip to SP9c**)
		SP9b		*Observe and record. If not evident from the outside ask the respondent to cut it open to discover*	1= orange fleshed sweet potatoes 2= white fleshed sweet potatoes 9= Don´t know
	Single choice	SP9c	**How often does your household get sweet potatoes?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to SP10)**
	Number	SP9d		*Enter number of days, weeks or months*	
	Single choice	SP10	**Do you also dry the fresh roots to produce flour or chips?**		1=Yes 2=No (**skip to SP14)**
	Single choice	SP11	**How do you usually dry the fresh roots?**		1=In the sun 2=In the shade 3= In the oven **(skip to SP9)** 4= Other
	Text	SP11_other	Type in the "other" option		
	Single choice	SP12	**For how long do you usually store the home made dried sweet potato chips or flour before consumption?**		
		SP12a			1= days 2= weeks 3= month 4= years 5= Don´t know **(skip to SP13)**
		SP12b		*Enter number of days or weeks or months*	
		SP13	**What proportion of the fresh sweet potatoes you usually consume are consumed as….**		
	Number	SP13a	Fresh roots?	*Record the number of*	

				pebbles (out of the total 10) on the fresh root pile	
	Number	SP13b	Flour?	*Record the number of pebbles (out of the total 10) on the flour pile*	
	Number	SP13c	(Other)?	*Record the number of pebbles (out of the total10) on the (other) pile*	
	Multiple choice	SP14	**How do you prepare FRESH ROOT sweet potatoes?**		
		SP14a	Boil?		1=Yes 2=No
		SP14b	Steam?		1=Yes 2=No
		SP14c	Fry?		1=Yes 2=No
		SP14d	Roast?		1=Yes 2=No
		SP14e	Bake?		1=Yes 2=No
		SP14f	(Other)?		1=Yes 2=No
		SP14f_other	Type in the "other" option		
		SP15	**What proportion of the FRESH ROOT sweet potatoes you usually consume are...**		
	Number	SP15a	Boiled?	**(Only ask this question if SP14a=Yes)** *Record the number of pebbles (out of the total 10) on the boiled pile*	
	Number	SP15b	Steamed?	**(Only ask this question if SP14b=Yes)**	

				Record the number of pebbles (out of the total 10) on the steamed pile	
	Number	SP15c	Fried?	**(Only ask this question if SP14c=Yes)** *Record the number of pebbles (out of the total 10) on the fried pile*	
	Number	SP15d	Roasted?	**(Only ask this question if SP14d=Yes)** *Record the number of pebbles (out of the total 10) on the roasted pile*	
	Number	SP15e	Baked?	**(Only ask this question if SP14e=Yes)** *Record the number of pebbles (out of the total 10) on the (other) pile*	
	Number	SP15f	(Other)?	**(Only ask this question if SP14f=Yes)** *Record the number of pebbles (out of the total 10) on the (other) pile*	
Knowledge, attitude and practice orange fleshed sweet potatoes (KAPSP)					
	Single choice	KAPSP1	**Have you ever heard of orange fleshed sweet potatoes?**	*Orange fleshed sweet potatoes = XYZ in Kinyarwanda* **Skip if SP5=1 or 3**	1=Yes 2=No **(skip to CA1)**
	Multiple choice	KAPSP2	**Where did you hear the first time about orange**	*Do not prompt. Probe "Anything*	

			fleshed sweet potatoes?	*else?" Record all responses mentioned*	
		KAPSP2a	Village/ community meetings		1=Yes 2=No
		KAPSP2b	Relatives/ friends/ neighbors		1=Yes 2=No
		KAPSP2c	Community health workers		1=Yes 2=No
		KAPSP2d	Community leaders		1=Yes 2=No
		KAPSP2e	Women groups		1=Yes 2=No
		KAPSP2f	Market place/ shop		1=Yes 2=No
		KAPSP2g	NGO		1=Yes 2=No
		KAPSP2h	Agricultural extension staff		1=Yes 2=No
		KAPSP2i	Projects (SUSTAIN, SASHA, Feed the Future….)		1=Yes 2=No
		KAPSP2j	TV		1=Yes 2=No
		KAPSP2k	Radio		1=Yes 2=No
		KAPSP2l	Billboards/wallpapers/ painted walls		1=Yes 2=No
		KAPSP2m	Other promotion activities		1=Yes 2=No
		KAPSP2n	Don't know		1=Yes 2=No
		KAPSP2o	Other (specify)		1=Yes 2=No (**skip to KAPSP3**)
	Text	KAPSP2oother	Type the "other" option		
	Multiple choice	KAPSP3	**What do you like about orange fleshed sweet potatoes?**	*Do not prompt. Probe "Anything else?" Record all responses mentioned*	

		KAPSP3a	Are good for vitamin A status		1=Yes 2=No
		KAPSP3b	Are good for the eyes		1=Yes 2=No
		KAPSP3c	Good for brain development		1=Yes 2=No
		KAPSP3d	Are good for health		1=Yes 2=No
		KAPSP3e	Good for development		1=Yes 2=No
		KAPSP3f	Taste		1=Yes 2=No
		KAPSP3g	Texture/ appearance		1=Yes 2=No
		KAPSP3h	Color		1=Yes 2=No
		KAPSP3i	Quality		1=Yes 2=No
		KAPSP3j	Price		1=Yes 2=No
		KAPSP3k	Crop yield		1=Yes 2=No
		KAPSP3l	Good for cooking		1=Yes 2=No
		KAPSP3m	Other (specify)		1=Yes 2=No (**skip to KAPSP4**)
	Text	KAPSP3m _other	Type the "other" option		
	Multiple choice	KAPSP4	**What do you NOT like about orange fleshed sweet potatoes?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
		KAPSP4a	Don´t trust them		1=Yes 2=No
		KAPSP4b	Not good for health		1=Yes 2=No
		KAPSP4c	Texture		1=Yes 2=No
		KAPSP4d	Taste		1=Yes 2=No
		KAPSP4e	Color		1=Yes 2=No
		KAPSP4f	Quality		1=Yes

					2=No
		KAPSP4g	Price		1=Yes 2=No
		KAPSP4h	Crop yield		1=Yes 2=No
		KAPSP4i	Other (specify)		1=Yes 2=No (**skip to KAPBB5**)
		KAPSP4i _other	Type the "other" option		
	Single choice	KAPSP5	**Do you know where to buy/ obtain orange fleshed sweet potato roots?**		1=Yes 2=No (**skip to KAPSP7)**
		KAPSP6	**Where can you buy or obtain orange fleshed sweet potato roots?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
			Shop		1=Yes 2=No
			Home grow orange fleshed sweet potatoes		1=Yes 2=No
			Farmer		1=Yes 2=No
			Market/street stand		1=Yes 2=No
			Moving street vendor		1=Yes 2=No
			Other (specify)		1=Yes 2=No **(skip to KASP7)**
			Type the "other" option		
	Single choice	KAPSP7	**Have you ever bought/ grown/ received orange fleshed sweet potato roots?**		1=Yes 2=No
		KAPSP8	**Where did you buy or obtain orange fleshed sweet potato roots?**	*Do not prompt. Probe "Anything else?"* *Record all responses mentioned*	
			Shop		1=Yes 2=No

			Farmer		1=Yes 2=No
			Market/street stand		1=Yes 2=No
			Moving street vendor		1=Yes 2=No
			Other (specify)		1=Yes 2=No **(skip to CA1)**
			Type the "other" option		
Cassava root consumption (CAR)					
	Single choice	CAR1	**Does your household consume cassava roots or prepare foods using fresh cassava roots at home?**	*This does not include industrially produced cassava products such as cassava flour. ONLY the fresh root.*	1=Yes 2=No **(skip to (CAF1)**
	Single choice	CAR2	**Does your household consume cassava roots or prepare foods using fresh cassava roots at home throughout the whole year?**		1=Yes (**skip to CAR4**) 2=No
	Multiple choice	CAR3	**During which months does your household consume cassava roots or prepare foods using fresh cassava roots at home in a typical year?**	*Select all months that apply*	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	CAR4	**The last time your household got fresh cassava roots, where did you get it from?**		1= Home grown 2= Local open market 3= Directly from farmer 4= Retail shop 5= Supermarket 6= Food aid 7= Gift 9= Don´t know **(skip to CAR5)** 8= Other (specify)

	Text	CAR4_other	Type the "other" option		
		CAR5	**The last time your household got fresh cassava roots, how much did you get?**	*If harvested, record total quantity from last harvest.* *If purchased, record the total quantity purchase.*	
	Single choice	CAR5a			1= Kilogram **(skip to CAR5d)** 2= Gram **(skip to CAR5d)** 3= Bag **(skip to CAR5c)** 4= Can 9= Don't know **(skip to CAR6)**
	Single choice	CAR5b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to CAR5d)** 8= Other
	Text		Type in the "other" option		**(skip to CAR5d)**
	Single choice	CAR5c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to CAR5d)** 8= Other
	Text		Type in the "other" option		
	Number	CAR5d	**How many?**	*Enter quantity*	
		CAR6	**How long does this amount usually last in your household?**		
	Single choice	CAR6a			1= days 2= weeks 3= months 9= don´t know **(skip to CAR6c)**
	Number	CAR6b		*Number*	

	Single choice	CAR6c	**How often does your household get cassava roots?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to CAR7)**
	Number	CAR6d		*Enter number of days, weeks or months*	
	Single choice	CAR7	**Do you use fresh cassava roots to produce flour or chips at home?**		1=Yes 2=No (**skip to CAR11)**
	Single choice	CAR8	**How do you usually dry the fresh cassava roots?**		1=In the sun 2=In the shade 3= In the oven **(skip to CAR9)** 4= Other
	Text	CAR8_other	Type in the "other" option		
		CAR9	**For how long do you usually store the home made dried chips or flour before consumption?**		
	Single choice	CAR9a			1= days 2= weeks 3= month 4= years 5= Don´t know **(skip to CAR10)**
	Number	CAR9b		*Enter number of days or weeks or months*	
		CAR10	**What proportion of the fresh cassava roots you usually consume are consumed as….**		
		CAR10a	Fresh roots?	*Record the number of pebbles (out of the total 10) on the fresh root pile*	
		CAR10b	Flour?	*Record the number of pebbles (out of*	

				the total 10) on the flour pile	
		CAR10c	(Other)?	*Record the number of pebbles (out of the total10) on the (other) pile*	
	Multiple choice	CAR11	**How do you prepare fresh cassava root?**		
		CAR11a	Boil?		1=Yes 2=No
		CAR11b	Roast?		1=Yes 2=No
		CAR11c	Ferment?		1=Yes 2=No
		CAR11d	(Other)?		1=Yes 2=No
	Text	CAR11d_other	Type in the "other" option		
		CAR12	**What proportion of the fresh cassava roots you usually consume are...**		
			Boiled?	**(Only ask this question if CAR11a=Yes)** *Record the number of pebbles (out of the total 10) on the boiled pile*	
			Steamed?	**(Only ask this question if CAR11b=Yes)** *Record the number of pebbles (out of the total 10) on the steamed pile*	
			Fermented?	**(Only ask this question if CAR11c=Yes)** *Record the number of pebbles (out of the total 10) on the fried pile*	

		CA7	Other?	**(Only ask this question if CAR11d=Yes)** *Record the number of pebbles (out of the total 10) on the roasted pile*	
Cassava flour consumption (CAF)					
	Single choice	CAF1	**Does your household buy cassava flour to prepare foods (such as, cassava bread)?**		1=Yes 2=No **(skip to (MAC1)**
	Single choice	CAF2	**Does your household use cassava flour to prepare foods throughout the whole year?**		1=Yes (**skip to CAF4**) 2=No
	Multiple choice	CAF3	**During which months does your household use cassava flour to prepare foods in a typical year?**	*Select all months that apply*	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	CAF4	**The last time your household got cassava flour, where did you get it from?**		1= Local open market 2= Directly from farmer 3= Retail shop 4= Supermarket 5= Food aid 6= Gift 9= Don´t know **(skip to CAR5)** 8= Other (specify)
	Text	CAF4_other	Type the “other” option		
		CAF5	**The last time your household got cassava flour, how much did you get?**		
	Single choice	CAF5a			1= Kilogram **(skip to CAF5d)** 2= Gram **(skip to CAF5d)** 3= Bag **(skip to CAF5c)**

					4= Can 9= Don't know **(skip to CAF6)**
	Single choice	CAF5b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to CAF5d)** 8= Other
	Text		Type in the "other" option		**(skip to CAF5d)**
	Single choice	CAF5c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to CAF5d)** 8= Other
	Text		Type in the "other" option		
	Number	CAF5d	**How many?**	*Enter quantity*	
		CAF6	**How long does this amount usually last in your household?**		
	Single choice	CAF6a			1= days 2= weeks 3= months 9= don´t know **(skip to CAF6c)**
	Number	CAF6b		*Number*	
	Single choice	CAF6c	**How often does your household get cassava flour?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to MAC1)**
	Number	CAF6d		*Enter number of days, weeks or months*	
Maize cob consumption (MAC)					
	Single choice	MAC1	**Does your household consume maize cobs or use fresh maize cobs to**	*This does not include industrially*	1=Yes 2=No **(skip to (MAF1)**

			prepare foods at home (such as, [insert local examples])?	*produced maize products such as maize flour. ONLY the fresh cobs*	
	Single choice	MAC2	**Does your household consume maize cobs or use fresh maize cobs to prepare foods at home (such as, [insert local examples]) throughout the whole year?**		1=Yes (**skip to MAC4**) 2=No
	Multiple choice	MAC3	**During which months does your household consume maize cobs or use fresh maize cobs to prepare foods at home (such as, [insert local examples]) in a typical year?**	*Select all months that apply*	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	MAC4	**The last time your household got fresh maize cobs, where did you get it from?**		1= Home grown 2= Local open market 3= Directly from farmer 4= Retail shop 5= Supermarket 6= Food aid 7= Gift 9= Don´t know **(skip to MAC5)** 8= Other (specify)
	Text	MAC4_other	Type the “other” option		
		MAC5	**The last time your household got fresh maize cobs, how much did you get?**	*If harvested, record total quantity from last harvest.* *If purchased, record the total quantity purchase.*	
	Single choice	MAC5a			1= Kilogram **(skip to MAC5d)** 2= Gram **(skip to MAC5d)** 3= Bag **(skip to MAC5c)**

					4= Can 5= Cobs **(skip to MAC5e)** 9= Don't know **(skip to MAC6)**
	Single choice	MAC5b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to MAC5d)** 8= Other
	Text		Type in the "other" option		**(skip to MAC5d)**
	Single choice	MAC5c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to MAC5d)** 8= Other
	Text		Type in the "other" option		
	Number	MAC5d	**How many?**	*Enter quantity*	
	Number	MAC5e	**How many?**	*Enter quantity*	
		MAC6	**How long does this amount usually last in your household?**		
	Single choice	MAC6a			1= days 2= weeks 3= months 9= don´t know **(skip to MAC6c)**
	Number	MAC6b		*Number*	
	Single choice	MAC6c	**How often does your household get maize cobs?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to MAC7)**
	Number	MAC6d		*Enter number of days, weeks or months*	

	Single choice	MAC7	**Do you use fresh maize cobs to produce maize flour?**		1=Yes 2=No (**skip to MAC11)**
	Single choice	MAC8	**How do you usually dry the fresh maize cobs?**		1=In the sun 2=In the shade 3= In the oven **(skip to MAC9)** 4= Other
	Text	MAC8_other	Type in the "other" option		
		MAC9	**For how long do you usually store the home made maize flour for consumption?**		
	Single choice	MAC9a			1= days 2= weeks 3= month 4= years 5= Don´t know **(skip to MAC10)**
	Number	MAC9b		*Enter number of days or weeks or months*	
		MAC10	**What proportion of the fresh maize cobs you usually consume are consumed as….**		
		MAC10a	Fresh?	*Record the number of pebbles (out of the total 10) on the fresh root pile*	
		MAC10b	Flour?	*Record the number of pebbles (out of the total 10) on the flour pile*	
		MAC10c	(Other)?	*Record the number of pebbles (out of the total10) on the (other) pile*	
	Multiple choice	MAC11	**How do you usually prepare fresh maize cobs?**		
		MAC11a	Boiled?		1=Yes 2=No
		MAC11b	Steamed?		1=Yes

					2=No
		MAC11c	Raw?		1=Yes 2=No
		MAC11d	Baked?		
		MAC11e	(Other)?		1=Yes 2=No
		MAC11e_other	Type in the "other" option		
		MAC12	**What proportion of the maize cobs you usually consume are...**		
			Boiled?	**(Only ask this question if MAC11a=Yes)** *Record the number of pebbles (out of the total 10) on the boiled pile*	
			Steamed?	**(Only ask this question if MAC11b=Yes)** *Record the number of pebbles (out of the total 10) on the steamed pile*	
			Raw?	**(Only ask this question if MAC11c=Yes)** *Record the number of pebbles (out of the total 10) on the fried pile*	
			Baked?	**(Only ask this question if MAC11d=Yes)** *Record the number of pebbles (out of the total 10) on the roasted pile*	
			Other?	**(Only ask this question if MAC11e=Yes)**	

				Record the number of pebbles (out of the total 10) on the roasted pile	
Maize flour consumption (MAF)					
	Single choice	MAF1	**Does your household buy maize flour to prepare foods (such as, [insert local examples])?**		1=Yes 2=No **(skip to (FR1)**
	Single choice	MAF2	**Does your household use maize flour to prepare foods (such as, [insert local examples]) throughout the whole year?**		1=Yes (**skip to MAF4**) 2=No
	Multiple choice	MAF3	**During which months does your household use maize flour to prepare foods (such as, [insert local examples]) in a typical year?**	*Select all months that apply*	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10=October 11=November 12=December
	Single choice	MAF4	**The last time your household got maize flour, where did you get it from?**		1= Local open market 2= Directly from farmer 3= Retail shop 4= Supermarket 5= Food aid 6= Gift 9= Don´t know **(skip to MAF5)** 8= Other (specify)
	Text	MAF4_other	Type the “other” option		
		MAF5	**The last time your household got maize flour, how much did you get?**		
	Single choice	MAF5a			1= Kilogram **(skip to MAF5d)** 2= Gram **(skip to MAF5d)** 3= Bag **(skip to MAF5c)** 4= Can

					9= Don't know **(skip to MAF6)**
	Single choice	MAF5b		*Enter size of can*	1= 25 liter 2= 20 liter 3= 10 liter 4= 5 liter 9= Don´t know **(skip to MAF5d)** 8= Other
	Text		Type in the "other" option		**(skip to MAF5d)**
	Single choice	MAF5c		*Enter size of bag*	1= 100 kg 2= 90 kg 3= 70 kg 4= 60 kg 5= 50 kg 6= 25 kg 7= 10 kg 9= Don´t know **(skip to MAF5d)** 8= Other
	Text		Type in the "other" option		
	Number	MAF5d	**How many?**	*Enter quantity*	
		MAF6	**How long does this amount usually last in your household?**		
	Single choice	MAF6a			1= days 2= weeks 3= months 9= don´t know **(skip to MAC6c)**
	Number	MAF6b		*Number*	
	Single choice	MAF6c	**How often does your household get maize flour?**		
					1= day 2= week 3= month 4= year 5= don´t know **(skip to FR1)**
	Number	MAF6d		*Enter number of days, weeks or months*	
Final result (FR1)					
	Single Choice	FR1	Final results codes		1=Interview successfully completed

					2= No household member or no competent respondent at home at time of visit 3= Entire household absent for long period or moved away 4= Refused 5= Dwelling vacant / Address not a dwelling 6= Dwelling destroyed 7= Dwelling not found 8= Other (specify)
	Text	FR1other	Type the “other” option		
Autofilled		FR2	Thank the respondent for his/her time		
Autofilled	Time	FR3	End time		

8.7 ADULT MALE EQUIVALENT (AME)

Table below with AME values for males and non-pregnant females was developed based upon data provided in FAO's Human Energy Requirements report [19].

Age range (years)		Males		Non-pregnant females	
		Energy (kcal/day)	AME	Energy (kcal/day)	AME
0.5	<1.0	661	0.22	661	0.22
1.0	<2.0	950	0.31	850	0.28
2.0	<3.0	1125	0.37	1050	0.34
3.0	<4.0	1250	0.41	1150	0.38
4.0	<5.0	1350	0.44	1250	0.41
5.0	<6.0	1475	0.48	1325	0.43
6.0	<7.0	1575	0.52	1425	0.47
7.0	<8.0	1700	0.56	1550	0.51
8.0	<9.0	1825	0.60	1700	0.56
9.0	<10.0	1975	0.65	1850	0.61
10.0	<11.0	2150	0.70	2000	0.66
11.0	<12.0	2350	0.77	2150	0.70
12.0	<13.0	2550	0.84	2275	0.75
13.0	<14.0	2775	0.91	2375	0.78
14.0	<15.0	3000	0.98	2450	0.80
15.0	<16.0	3175	1.04	2500	0.82
16.0	<17.0	3325	1.09	2500	0.82
17.0	<18.0	3400	1.11	2500	0.82
18.0	<30.0	3050	1.00	2400	0.79
30.0	<60.0	2950	0.97	2350	0.77
60.0	110.0	2450	0.80	2100	0.69