Market Surveillance Study for Fortified Foods in Uganda

Study Report

SEPTEMBER 2023

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1.0 Introduction

1.1 Micronutrient Status and Dietary Patterns in Uganda

Micronutrient malnutrition, commonly called "hidden hunger," is a major public health problem in low- and middle-income countries and industrialized countries (USAID 2022). It is commonly due to either insufficient intake or impaired absorption and utilization of one or more vitamins or minerals, commonly vitamin A, vitamin B12, folate, and other B vitamins like riboflavin and niacin, and iodine, iron, and zinc. It is called hidden hunger because the effects of the deficiency usually go unnoticed in the early stages and are only clinically apparent when the micronutrient deficiencies have progressed to a severe level.

Micronutrient deficiencies affect all age groups, though preschool children and women of reproductive age represent the populations with the highest risk. Micronutrient deficiencies are measured using biomarkers and bioindicators, with biochemical or functional status correlated with health and nutrition outcomes. For example, anemia due to low hemoglobin is a bioindicator that reflects the deficiency of critical micronutrients like iron, vitamin A, folate, and vitamin B12 and/or an underlying inflammatory process that does not allow the utilization of micronutrients for red blood cell formation.

Micronutrient deficiency was identified as a major public health problem in Uganda, and over time, there is notable improvement in the reduction of iodine, vitamin A and folate deficiencies. The Uganda Bureau of Statistics, which conducts the Uganda National Panel Survey (UNPS), reported that the prevalence of anemia in preschool children and women of reproductive age was 32 and 17 percent, respectively. They also reported that iron deficiency anemia in children and in women was 7 percent for both groups while the prevalence of iron deficiency was determined to be 14 percent and 17 percent, respectively. They further reported that vitamin A deficiency in Uganda, measured using the modified relative dose response test, was 5 percent and 1 percent for children and women, respectively (UBOS and CDC 2020). These results suggest that vitamin A deficiency is a mild public health problem for children and not a public health problem for women in Uganda. The UNPS also reported that vitamin B_{12} deficiency, measured by serum B12 <203 pg/mL, was seen in 5 percent of pre-school children and 9 percent of non-pregnant WRA. Folate deficiency, as measured by serum folate <7.0 nmol/L, was seen in 1.5 percent of pre-school children and 4 percent of WRA. Equally, measuring the status of other micronutrients, such as zinc and vitamin B_2 for comparison, might be warranted, because they were not measured in this surveillance cycle. The median urinary iodine concentration (UIC) of 197.5 µg/L among pregnant women is within the World Health Organization's (WHO) recommended range (>150 ug/L), which suggests that iodine deficiency disorders are no longer a public health problem in the country. This success is due to almost all (99.3 percent) of the salt has iodine concentration greater than 15 mg/kg of salt.

The World Food Programme's 2019 *Fill the Nutrient Gap* report for Uganda found that "nearly three-quarters (73 percent) of the population cannot afford a nutritious diet, a trend that is widespread across the regions," and predicted that an increase in consumption of less-nutrient-dense staple crops will likely have a negative impact on micronutrient intake (WFP, Government of Uganda Office of the Prime Minister, and UNICEF 2019). Relatedly, the UNPS for 2018–19 indicates the performance indicators for dietary diversity, with 17 percent of children ages 6–23 months receiving a minimum dietary diversity (consuming four or more food groups), one in two (51 percent) meeting the minimum meal frequency, and 1 in 10 (11 percent) achieving a minimum acceptable diet. This is similar to only 16 percent of women ages 15–49 years who receive minimum dietary diversity (consuming five or more food groups). These results show that dietary practices in Uganda are insufficient to meet the nutrient needs of children and women.

1.2 Overview of the Food Fortification Program in Uganda

Food fortification is a key part of Uganda's national strategy to reduce micronutrient deficiencies. Food fortification is the addition of one or more essential nutrients to an industry-manufactured food, whether or not the food normally contains such nutrients, to prevent or correct a demonstrated deficiency of one or more nutrients in the population or specific population groups (Allen et al. 2006).

Uganda's favorable public- and private-sector environment led to its adoption of a cost-effective food fortification program, starting with salt iodization in the early 1990s up to its current version, followed by standards for the fortification of oil, sugar, and cereal flours in the early 2000's, Nowadays, fortification is compulsory for salt with iodine, edible oils and fats with vitamin A, and wheat flour and maize meal manufactured by medium and large industries with multiple micronutrients. Food fortification in Uganda is supported by the Food and Drug Act of 1959 (MOH 1959); the Food and Drugs (Food Fortification) Regulations of 2005 (MOH 2005); the Food and Drugs (Food Fortification) (Amendment) Regulations of 2011 for wheat flour, maize meal, edible oils, and fats (MOH 2011); and the Foods and Drugs (Control of Quality) (Iodated Salt) Regulations of 1997 for salt (MOH 1997). Additional existing operational tools and guidelines for ministries, departments, and agencies include the national food fortification strategy and national standards.

Since the introduction of mandatory regulations in Uganda, some progress has been made in monitoring the quality and safety of fortified foods using set standards for different food vehicles and continuous collection, review, and use of performance information on program implementation. Per the 2015 Fortification Assessment Coverage Tool survey, 85 percent of oil samples, 30 percent of maize flour samples, 76 percent of wheat flour samples, and 99 percent of salt samples at the household level were fortified (GAIN 2017). The UNPS found that 83 percent of vegetable oil samples and 99 percent of salt were fortified.

A market social audit study conducted by FFI in 2019[1] found that 55 percent of vegetable oil brands met the Uganda national standards of Vitamin A in oils, in phase 1 (2018) and improved to 97.4 percent in phase II (2019). The same study reported that 70 percent of wheat flour brands met the standards of total added iron in wheat flour, which improved to 93.6 percent in the phase II. The improvements noted in phase II, was assumed to have been achieved after an advocacy intervention by parents to Spina-bifida victims. However, only 10 percent of maize flour brands met the standards of added total iron in maize flour, and this reduced to 6.9 percent in phase II.

The UNPS national data of 2018/19 on adequacy of fortification in oil and fat samples collected at households showed that 82.6 percent of the edible oil samples showed presence of vitamin A at the household level with a mean retinol content of 18.5 mg/kg, which means that most samples of oil were found as fortified, and with amounts enough to provide a large contribution to the daily requirements of this vitamin A among the population. However only 38.8 percent and 42.9 percent of fortified edible oil was within the 20–40 mg/kg of the national standards, which is a criterion applicable only at the production or factory level (UBOS 2020; UBOS 2022). Retinol levels of 18.5 mg/kg would supply 92µg to 185µg of vitamin A assuming the edible oil intake is 5–10 g/day, thus contributing to 18–37 percent of the daily vitamin A requirements of an adult woman, which possibly could be the main source of vitamin A. The vitamin A intake depends on the amount of the edible oil consumed, and should be within the recommended daily intake. These results indicate that the edible oil fortification program is working; however, frequent and systematic monitoring is still required to maintain the quality of this program. The UNPS also found that 45.9 percent of cooking fat was fortified with a mean retinol content of 13.2 mg/kg and a median of <6.0 mg/kg. However, only 9.4 percent of fortified edible oil was within the 20–40 mg/kg of the national standards, which is applicable only at the production or factory level. The limit of detection for evaluating retinol in edible oils and fats in this study was 6 mg/kg. This means that more

[1] https://www.ffinetwork.org/ffimedia/africa-regional-highlights-malawi-and-uganda

than half (54.1 percent) of the edible fat samples were either not fortified to begin with or no longer contained detectable concentrations of vitamin A by the time it reached the household (UBOS 2020; UBOS 2022).

1.3 Study Rationale

Regulatory monitoring is critical for continuous collection and review of information at key delivery points in the production and trade chain to ensure that fortified foods meet national standards. In Uganda, this is achieved through a multi-agency system at the import, industry, and market levels. Several conditions must be in place for national food fortification programs to be impactful (Neufeld et al. 2017). They include effective quality control, inspection, and monitoring systems to ensure the availability and safety of high-quality fortified food in the market.

Market/commercial monitoring, also known as market surveillance of fortified foods, occurs at retail points-of-sale and is part of the national strategy to assess industries' compliance with national standards, enhance consumer protection, and promote fair trade. Although the government has led efforts in market surveillance, this has not been routine because of limited resources by key institutions. Information gaps also exist on the performance of the fortification program. A market surveillance survey is necessary to assess the availability and adequacy of various micronutrients in the four mandatory food vehicles (maize flour, wheat flour, edible oils and fats, and salt) at retail. It also complements production and consumption data to assess and track performance of the program across the fortification value chain, from imports/border, production and retail to consumption. Civil society will use any results showing poor performance to advocate for strengthening regulatory actions with different stakeholders along the value chain to improve the quality and safety of the fortified products.

1.4 Study Objectives

The aim of the study was to determine the availability of the existing fortified food brands at the retail level and the presence and adequacy of the required micronutrients in the four fortified food vehicles (edible oils and fats, wheat flour, maize meal, and food-grade salt) in Uganda.

The specific objectives of the study were to—

1. Determine the availability of fortified food brands at select sentinel sites[2]
2. Determine the fortification quality of brands of a food vehicle using two methods:
    - Assess the presence of iron, vitamin A, and iodine in individual samples of fortified foods at the retail level using qualitative tests
    - Determine the concentrations of iron, zinc, vitamin A, and iodine in the fortified food samples using quantitative tests to assess their compliance with Ugandan national fortification standards.

[2] "Availability" refers to the total number of locally certified brands of a food vehicle that are available on the market.

2.0 Design and Methods

The market surveillance study followed a cross-sectional survey design to address the two objectives. To address objective 1, study investigators collected food samples from selected sentinel sites across the country and established the availability of the different brands of specific food vehicles on the market.

To address objective 2, the different food samples were carefully collected, labeled, packed, stored, and transported to Chemiphar Uganda Ltd, a recognized and accredited central laboratory that led analysis of qualitative tests to determine the presence of micronutrients (vitamin A, iron, and iodine) and quantitative tests of samples that passed the qualitative tests to determine the concentration of micronutrients (vitamin A, iron, zinc, and iodine) in each food vehicle. Compliance with national fortification standards was done in composite samples per brand when more than one sample was collected for the brand. Samples were picked across the country, covering the four major regions in Uganda (Central, Northern, Eastern, and Western), 16 sub-regions and 29 districts as seen in *table 1*, and targeting sentinel sites (districts of high business concentrations identified from the Uganda Bureau of Statistics business census report [UBOS 2011]). At least one sentinel site was selected from each of the 16 sub-regions from the four major regions listed above. By definition, a sentinel site is a community from which in-depth data is gathered and the resulting analysis is used to inform programs and policies affecting a larger geographical area (FoodNet Canada 2015). For the purposes of this study, the sentinel sites are selected districts with high concentrations of business/trade relative to the subregions as indicated in Table 1. Within the identified sentinel sites, marketplaces (large concentrations of retail outlets) were purposely selected based on geographical distribution and diversity of retail outlet types present. Retail outlets were identified by the field teams to purchase the food samples of interest, either labeled as "fortified" or with an F-logo, as part of a normal business transaction.

The purchase of food samples included buying samples of all four food vehicles—maize meal, wheat flour, edible oils and fats, and salt—at three different retail points—supermarkets, retail shops, and kiosks. The choice of the fortified food brands picked from the market were guided by the findings from the 2022 *Capacity Needs Assessment for Food Processors*, the Uganda National Bureau of Standards, the 2023 Certification Information Management System, and what was available in the market. We also included imported salt products and wheat flour samples that we found on the market shelves. Food samples were picked from 16 subregions and 29 districts across the four major regions of Uganda following the concentration of business/trade to ensure that we did not miss any food brands on the market (Table 1).

Table 1: List of Sentinel Sites Visited

Region	Sub-region	District/ Sentinel sites
Central A	Greater Kampala	Kampala
		Lugazi
		Mukono
		Wakiso
Central B	North Central	Mityana
		Mubende
	South Central	Bukomansimbi
		Kalungu
		Masaka

Region	Sub-region	District/ Sentinel sites
		Ssembabule
Eastern	Bugisu	Mbale
	Busoga	Iganga
		Jinja
	Karamoja	Moroto
	Sebei	Kapchorwa
	Teso	Soroti
Northern	Acholi	Gulu
	Lango	Lira
	West Nile	Arua
		Nebbi
Western	Ankole	Ishaka
		Mbarara
		Ntungamo
	Bunyoro	Hoima
	Rukiga	Kabale
		Rukungiri
	Rwenzori	Kasese
	Tooro	Kabarole
		Kyenjojo

The criteria for sample purchase (for maize flour and edible oils and fats) was based on the claim that the product was fortified, enriched, or had added vitamins and minerals and/or the product had a food fortification logo (the F-logo). Wheat flour and food-grade salts were universally picked because they are mandatory to fortify per the food fortification regulations and standards. The food samples were coded and thereafter transported to the Chemiphar laboratory for qualitative and quantitative analysis.

Based on World Health Organization guidelines for flour fortification monitoring (WHO 2021), at least one sample was targeted per brand per region using the data collection tools described in *Annex 1*. A total of 216 food samples were collected across the country, as summarized in Table 2, and prepared for qualitative analysis to determine the presence of specific micronutrients, and 155 composites were established for quantitative analysis to determine the concentration of micronutrients. Sample composites were based on:

1. Brand - For samples that qualitatively tested positive for all the micronutrients were mixed to form a composite.
2. Parameters - samples of the same brand which had different results for the different micronutrients were composited differently.

Table 2. Summary of Food Samples Collected

Food Vehicle	Edible Fats	Edible Oils	Edible Salt	Maize Flour	Wheat Flour	Total Samples
Central A	3	16	15	7	18	59
Central B[3]	1	12	5	0	9	27
Eastern	2	17	10	3	18	50
Northern	2	15	6	2	12	37
Western	3	15	13	3	9	43
Total	11	75	49	15	66	216

The statistical analysis of data preceded the laboratory technical analysis, using descriptive analyses (frequency counts and proportions) to describe the availability and distribution of the different fortified food brands by food vehicle and region. The laboratory analysis tested the presence and concentrations of iron, vitamin A, and iodine in the individual samples qualitatively and tested the composite food brands in comparison to the Ugandan national fortification standards. Results were presented as tables and control charts to depict the presence or absence of specific micronutrients and the micronutrient concentrations in individual composite samples by producers or brands.

2.1 Laboratory Technical Analysis of Samples

The collected food samples from the sentinel sites and market/retail outlets were subjected to qualitative analysis for the presence of specified micronutrients as prescribed in the standards for fortified foods for the four food vehicles (see details in Table 3). Chemiphar Uganda Ltd, an accredited laboratory, used traditional qualitative methods of analysis (standardized East Central and South Africa (ECSA) methods) to depict the presence of the specific micronutrients in the different food samples.

The samples that tested positive for qualitative analysis were composited based on specific brands and subjected to quantitative micronutrient analysis. A general description of the analytical methods applied to food samples appears in Annexes 2 and 3.

Table 3: Qualitative and Quantitative Analysis Methods

Food Vehicle	Parameter	Qualitative Analysis Method	Quantitative Analysis Method
	Vitamin A	ECSA, part III, method C	AOAC* Official Method 2001.13
	Total Iron	ECSA, part III, method B for iron	AOAC Official Method 944.02
			AOAC Official Method 944.02
Edible Oils	Vitamin A	ECSA, part II, Annex B	AOAC Official Method 2001.13
Edible Salt	Iodine	ECSA, part I, method B	AOAC Official Method 935.14

*Association of Official Analytical Chemists (AOAC)

The study analysis scope in Table 3 presents the list of micronutrients added to the respective food vehicles in the process of fortification per the Ugandan national regulations and standards and the

[3] The Central region was divided into Central A and Central B because of its diverse geographical scope, diverse business activities, and especially the levels of the food industry characteristics as explained further under "Key Findings."

suggested methods of analysis. The required reference ranges for each specific micronutrient are detailed in Annex 3 for each food vehicle.

The laboratory analysis, as described above, began with qualitative analysis, and samples that tested positive for specific micronutrients were then quantitatively analyzed.

3.0 Key Findings

3.1 Availability of Food Brands Labeled as Fortified in the Market

3.1.1 Fortified Food Samples Available Across the Regions

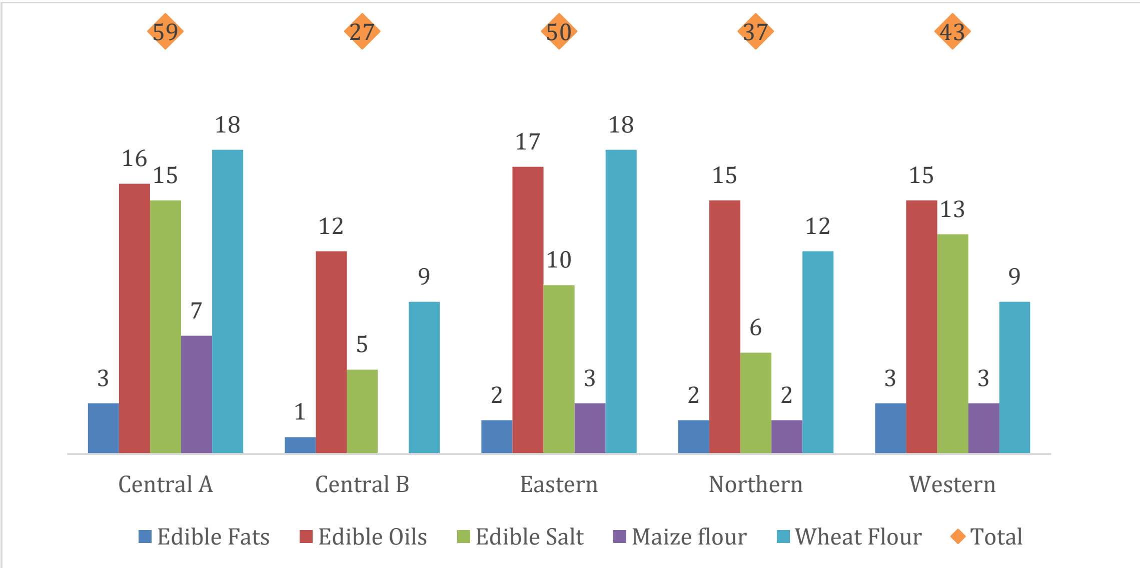
Overall, 216 samples were collected across the four regions, including: a) 49 salt samples from 24 brands—18 of which were imported, only one locally produced, and five locally repackaged; b) 75 edible oil samples from 17 local brands; c) 11 fat samples from three local brands; d) 15 maize flour samples from eight local brands; and e) 66 wheat samples from 29 brands—seven of which were imported and 22 locally produced. There was a concentration of manufacturers that produced the brands that we samples—24 salt samples from 17 industries, 17 edible oil brands from eight industries, three edible fat brands from 2 industries, eight maize flour brands from eight industries, and 29 wheat flour brands from 21 industries.

Figure 1 shows the distribution of samples collected from brands labeled fortified across the regions (86 samples from Central [59 from Central A and 27 from Central B]; 50 samples from Eastern; 37 from Northern; and 43 samples from the Western region).

Central A had the majority of the labeled fortified food vehicles, which can be attributed to the fact that Wakiso and Kampala districts, which are highly populated, are located in the region. Kampala, the capital city of Uganda, has the biggest business presence, as a city hub that supplies all the regions, in addition to having the majority of the fortifying industries centralized within its center. This potentially provides more access to the fortified food brands. Similarly, all regions had all the fortified brands, though some regions registered more food samples than others. For example, the Eastern region had samples of wheat and edible oils that were similar to Central A. An interesting finding was the absence of maize flour samples labeled as fortified in Central B, which is known for a high concentration of micro, small, and medium millers who do not fortify their maize flour; they believe that fortified maize flour from Kampala is of inferior quality compared to unfortified maize flour produced within Nyendo-Masaka district, for example. Relatedly, in the Mubende district in Central B, no fortified maize flour was found in the retail shops, yet Ugali fortified maize flour has a depot within the town.

In the Eastern region, fortified maize flour was rarely found in markets across the region. Only three samples were collected and only one brand sold in large quantities like 10 kilograms, and the majority of the fortified maize flour outlets were not easily accessible. The same applied to the Western region, with only three brands of fortified maize flour, and the Northern region, with only two brands. The majority of the fortified wheat flour used in Kapchorwa district within the Eastern region was imported because of their low cost of Ugandan Sh. 70,000 per carton, compared to Ugandan Sh. 90,000 for locally produced wheat flour. Maize flour and edible fat samples were few across all four regions, which indicate fewer industries that are fortifying these food vehicles. Details of the distribution of the specific brand names labeled as fortified across the four food vehicles are in Annex 4.

Figure 1. Available Fortified Foods in the Market by Region



In summary, all food vehicles labeled as fortified were available across the four main regions. Greater numbers of brands of edible oils, salt, and wheat flour were present across the regions while fewer number of edible fats and maize flour were found across the regions. It is worth noting that most salt is imported into Uganda. The initial plan was to only collect locally produced wheat flours; however, about seven brands imported from neighboring Kenya were mostly used in Kapchorwa district, located in the Eastern region, and only one of them (Unga Exe Self Raising Fortified Wheat Flour) was found in the Western and Central regions.

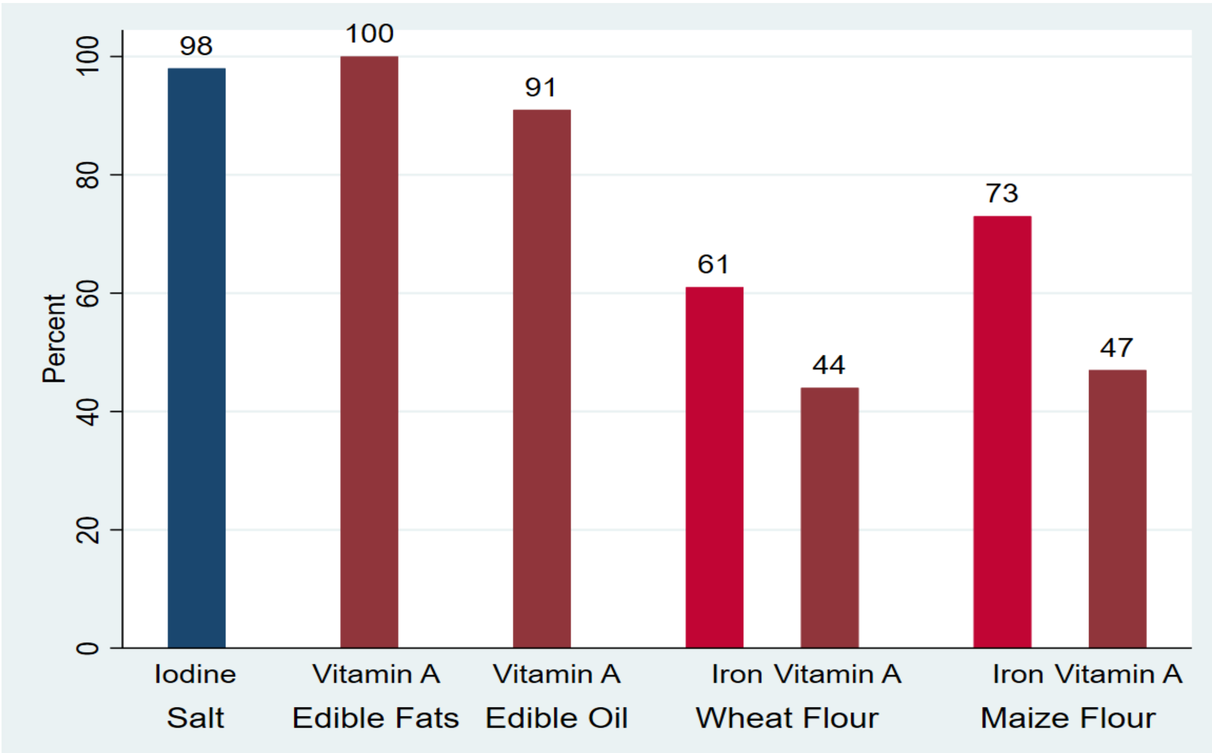
3.2 Qualitative Test Results Showing the Presence or Absence of Micronutrients in the Food Samples with a Fortification Claim

This section shows the concentration of qualitative test results of micronutrients in the food brands. Details of the qualitative tests results of food samples by brands are in *Annexes 5 and 6*.

3.2.1 Presence or Absence of Micronutrients in the Food Samples by Food Vehicle

The findings from the qualitative analysis of 216 samples, as detailed in **Figure 2**, showed that almost all (98 percent or 48/49) of **salt** samples from 24 brands contain iodine, and all of the **edible fat** samples (11) from three brands and 91 percent (68/75) of the **edible oil** samples from 17 brands contained vitamin A. 60 percent (40/66) of wheat flour samples contained iron in amount that could be considered as fortified, and 44 percent (29/66) contained vitamin A. The study also revealed 73 percent (11/15) of maize flour samples contained iron, and 47 percent (7/15) contained vitamin A.

Figure 2. Proportion of Food Samples (Edible Fats, Edible Oils, Maize Flour, Salt, and Wheat Flour) which Contained any Added Micronutrients, as Tested Qualitatively



The key takeaway from the qualitative tests is this: while it was easy to measure the presence or absence of micronutrients in salt and edible fats and oils with single micronutrients, there was inconsistency for wheat and maize of the same brands, particularly for iron and vitamin A.

3.3 Quantitative Test Results Showing the Concentrations of Micronutrients in the Fortified Food Brands

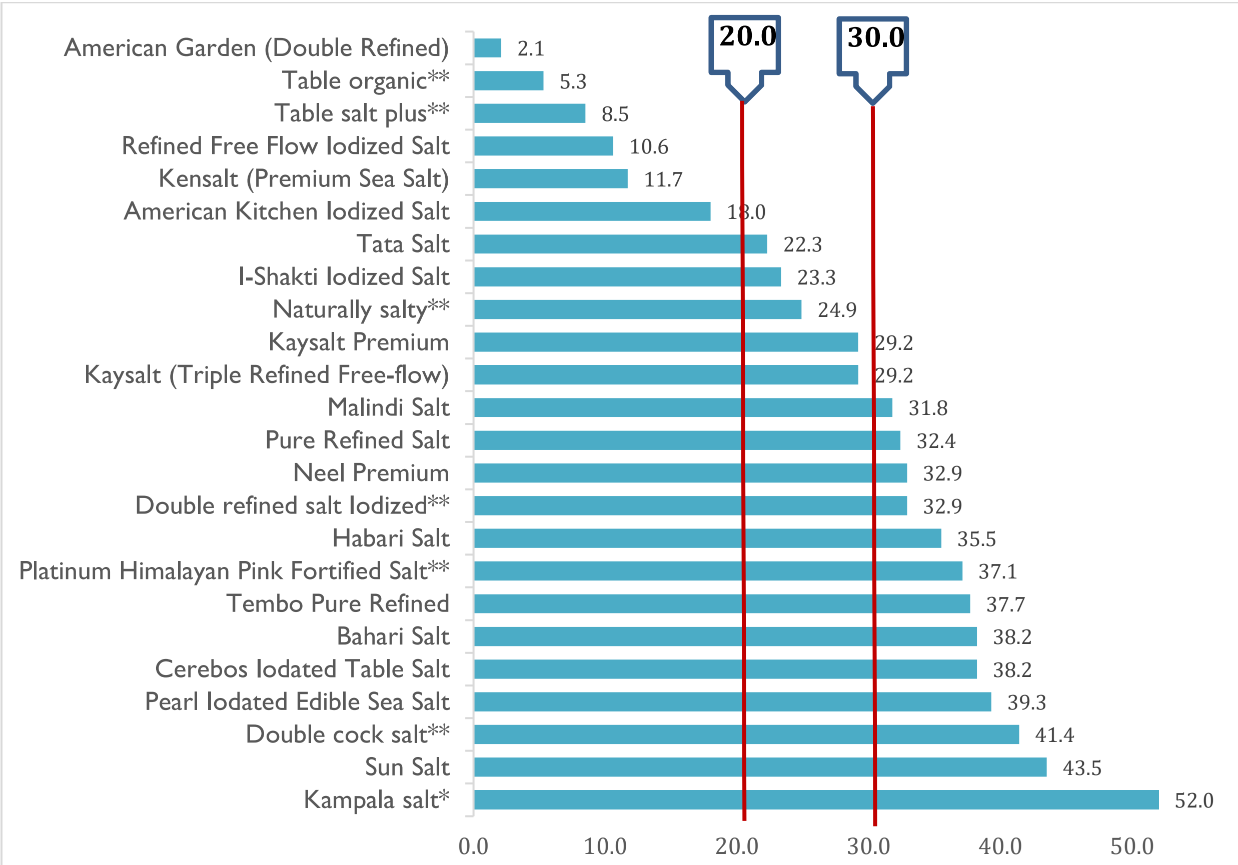
This section shows the concentration of quantitative test results of micronutrients in the food brands. Details of quantitative results are in *Annex 7*.

3.3.1 Iodine Concentrations in Salt Brands

According to the Ugandan standard US EAS 35-Fortified edible salt specifications, the acceptable range of added salt is 30–60 milligram/kilogram (mg/kg). The average iodine content across 24 brands was 28.3 mg/kg (95 percent confidence interval (CI): 22.7–33.8 mg/kg). All 24 brands that passed the qualitative tests were composited for quantitative tests. Findings from the study, as shown in **Figure 3**, show that the average concentration of iodine in the salt brands was 28.3 mg/kg (range: 2.1–52.0 mg/kg, 95 percent CI: 22.7–33.8 mg/kg), and 54 percent (13/24) of the salt conformed to the food fortification standards for iodine, one of which (Kampala Salt) was locally produced and three (Double Refined Salt Iodized, Double Cock Salt, and Platinum Himalayan Pink Fortified Salt) were locally repackaged salt products. There were 11 imported salt brands that had iodine values below the required minimum of 30 mg/kg, but were allowed to be imported based on the labeling indicating the range of iodine on their labels, including Balaji (15–30 mg/kg), Tata (20 mg/kg), and Zee (>15 mg/kg). Four local brands that were repackaging companies did not conform to the national standards (Naturally Salty, Table Organic, and

Table Salt Plus; **Figure 3**). Given that Uganda allowed for importation of salt samples below the production minimum cutoff of 30 mg/kg, we used a lower minimum cutoff of 20 mg/kg to denote acceptable iodine levels. With a 20 mg/kg cutoff, six samples (25 percent) will not meet that cutoff, of which two brands (Table Organic, and Table Salt Plus) are local brands.

Figure 3. Iodine Concentrations (mg/kg) in 24 Composited Salt Brands

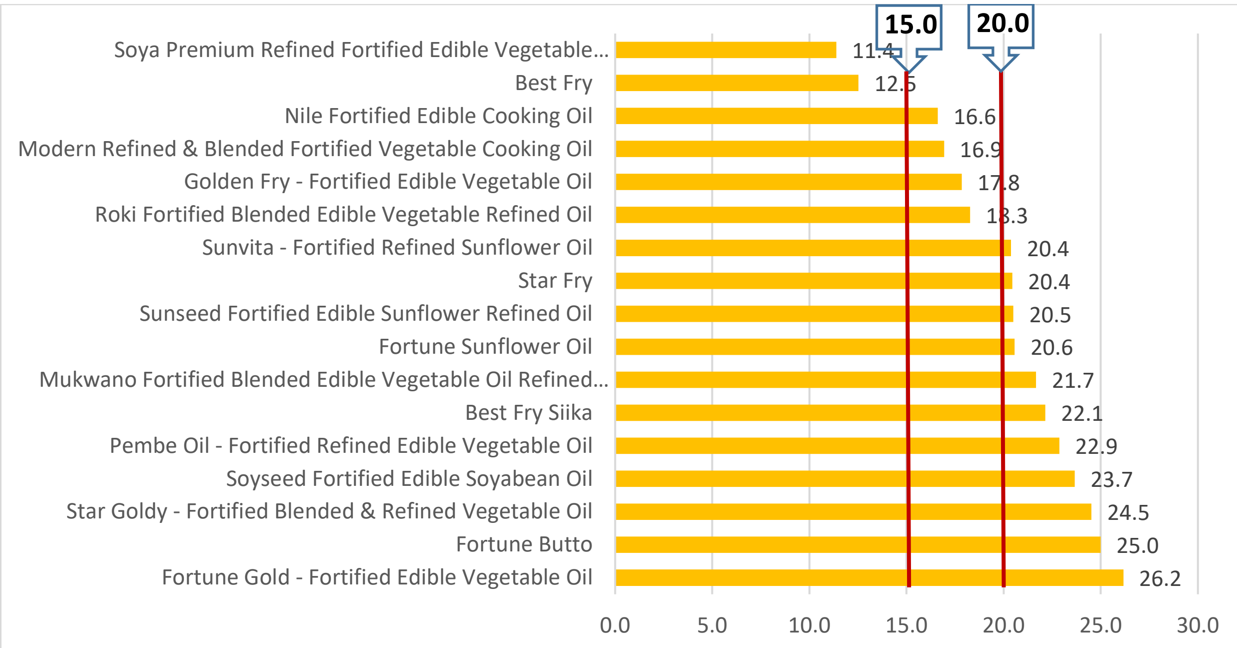


* Locally produced iodized salt
** Locally repackaged salt

3.3.2 Vitamin A Concentrations in Edible Oil Brands

According to the Ugandan standard US EAS 769- Fortified edible-specifications, the acceptable range of added **vitamin A is 20–40 mg/kg.** All 17 brands that passed the qualitative tests were composited for quantitative tests. As seen in **Figure 4**, the average concentration of vitamin A reported in µg retinol activity equivalents/kg for edible oils was 20.1 (range: 11.4–26.2, 95 percent CI: 18.0–22.2 mg/kg). Eleven brands conformed to the food fortification standards for vitamin A. Based on the sample distribution from the limited number of samples, it appears that the edible oil industry is adding vitamin A with the aim of getting an average concentration of 20.1 mg/kg, instead of adding more vitamin A to move it closer to the mid-point of the acceptable range. With that in mind, and with the small sample size, if we use 15 mg/kg as the lower bound of the acceptable concentration, we see that only two brands do not meet the cutoff.

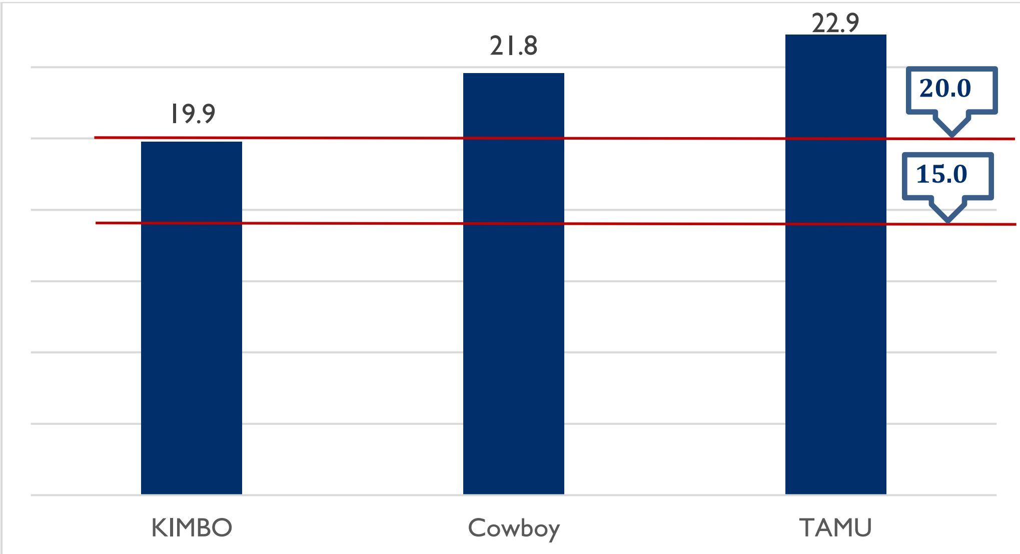
Figure 4. Vitamin A Concentrations (mg/kg) in 17 Composited Edible Oil Brands



3.3.3 Vitamin A Concentrations in Edible Fat Brands

According to the Ugandan standard US EAS 769: Fortified edible fats specifications, the acceptable range for added **vitamin A is 20–40 mg/kg**. All three brands that passed the qualitative tests were composited for quantitative tests. As seen in **Figure 5**, the average concentration of vitamin A reported in µg retinol activity equivalents/kg in edible fats was 21.6 (range: 19.9–22.9 mg/kg, 95 percent CI: 17.8–25.3 mg/kg). As with edible oil, the edible fat manufacturers are aiming for an average vitamin A content of 20 mg/kg and thus adding enough fortificant to get an average content around 20 mg/kg, instead of adding more fortificant to move the vitamin A concentration to the mid-point of the acceptable range. With these three samples, we can therefore assume that all samples were fortified, even the Kimbo brand whose single measurement tested below the cutoff but can be considered compliant as it falls within the measurement error of the assessment method. For the reasons considered above, using a 15 mg/kg cutoff, we note that all edible fat samples have sufficient vitamin A.

Figure 5. Vitamin A Concentrations (mg/kg) in Three Composited Edible Fat Brands



3.3.4 Concentrations of Total Iron, Zinc, and Vitamin A in Maize Flour

According to the US EAS, 678: Fortified milled maize (corn) product specifications, the acceptable range is 0.5–1.4 mg/kg for vitamin A and 33–65 mg/kg for zinc, and total iron has a minimum of 20 mg/kg and no maximum limit.

Of the 73 percent (11/15) maize samples that passed qualitatively for iron from six brands, only five of the six composited brands passed. The average iron concentration in the five maize flour brands was 50.5 mg/kg (range: 21.3–76.1 mg/kg, 95% CI: 25.6–75.5 mg/kg). Overall, 63 percent (5/8) brands met the standards requirement for total iron in maize flour. Of the 47 percent (7/15) individual maize samples from three brands that passed qualitatively for vitamin A, two of the three composited brands passed quantitatively. The average vitamin A concentration in the three maize brands was 0.5 (the three samples showing 0.45, 0.5, and 0.46 mg/kg), with five brands out of eight registering no vitamin A at all. Overall, only 25 percent (2/8) of brands met the Uganda standards requirements for vitamin A for maize flour though if we lowered the minimum value to 0.3 mg/kg, then 38 percent of the brands met the minimum requirement for vitamin A. Two maize brands that showed no presence of iron during the iron spot test showed low levels of iron when tested quantitatively (King Fortified Maize Flour at 4.69 mg/kg and Ugali at 4.8 mg/kg), which reflects intrinsic iron. See **Table 4** for details.

The average zinc concentration in the four maize flour brands was 25.3 mg/kg (range: 0.9–53.3, 95 percent CI: 6.4–44.2 mg/kg). Overall, 50 percent (4/8) brands met the standards requirement for zinc in maize flour. See Table 4 for details.

Table 4. Brands of Wheat and Maize Flour with Absence of Iron in Qualitative Tests and Iron detected in Quantitative Analysis for Total Iron Content

Product Brand(s)	Qualitative	Quantitative
	Absent	Total Iron content (mg/kg)
MAIZE FLOUR: Acceptable Limit 21 mg/kg		
King Fortified Maize Flour	Absent	4.69*
Ugali Fortified Maize Flour	Absent	4.8*

WHEAT FLOUR: Acceptable limit 20 mg/kg		
Angel Home Baking Flour	Absent	21.3
Drum Atta Fresh	Absent	28.8
Everyday Fortified Atta Flour	Absent	24.5
Gold Medal Home Baking Wheat Flour	Absent	17.2
Modern Fortified Home Baking Wheat Flour	Absent	26.7
Nile Fortified Home Baking Wheat Flour	Absent	32.0
Nile Fortified Home Baking Wheat Flour–Unuga Safi Wa Ngano	Absent	22.8
Tembo - Fortified Home Baking Flour	Absent	24.8

Table 5. Concentrations of Total Iron, Zinc, and Vitamin A in Maize Flour

Maize Flour Brands	Acceptable Range of added Total Iron [>=21 mg/kg]	Acceptable Range of added Vit A [0.3–1.4 mg/kg]	Acceptable Range of added Zinc [33–65 mg/kg]	Remarks (Based on Standards and Micronutrients)
Fortified Maize Flour - Meal Life	76.1	0.45	53.3	Passes
Jjimu Fortified Maize Flour	55.5	0.50	45.2	Passed
Joha	43.4	0.00	10.0	Failed for vit. A and zinc
King Fortified Maize Flour	4.69	0.00	0.87	Failed for everything.
Kob Posho	56.4	0.00	41.4	Failed for vit. A
Maganjo Maize Flour	13.3	0.00	6.2	Failed for everything
Supreme Fortified Maize Flour	21.3	0.46	44.1	Passed
Ugali	4.8	0.00	1.3	Failed for everything

3.3.5 Concentrations of Total Iron, Zinc, and Vitamin A in Wheat Flour

According to US EAS, 678 Fortified wheat flour specifications, the acceptable range for vitamin A is 0.5–1.4 mg/kg and 40–80 mg/kg for zinc, and total iron has a minimum of 21 mg/kg with no maximum limit.

From the analysis of wheat, 53 percent (40/75) wheat samples passed qualitatively for iron from 21 brands and all were composited. In addition, 20 percent (15/75) samples from eight brands were tested qualitatively, and results showed an absence of iron. All eight brands that showed an absence of iron were composited. The average iron concentration in the 29 total wheat flour brands was 32.5 mg/kg (range: 17.2–55.3 mg/kg, 95% CI: 29.0–35.9 mg/kg). The eight brands that did not show iron content by the qualitative test are included in the 29 brands, and 7/8 passed the quantitative test for total iron, as detailed in Table 5. Overall, 97 percent (28/29) of the brands met the standards requirement for total iron in wheat flour. Seven wheat brands showed no presence of iron during the iron spot test, but when tested quantitatively showed iron concentrations. This could be attributed to the form of premix used and whether it contained iron in the acceptable form (NaFeEDTA or ferrous fumurate) compatible with the quantitative spectrophotometric method for determining total iron in flour.

Of the 44 percent (29/66) of wheat samples that passed qualitatively for vitamin A, 48 percent (14/29) of the brands had quantifiable Vitamin A concentration averaged at 0.39 mg/kg (range: 0.22–0.53, 95% CI: 0.3–0.4 mg/kg), with 15 brands registering no vitamin A. Using the lower bound of the Uganda national cutoff of 0.5 mg/kg, three of the 14 brands (21 percent) had values higher than the minimum national standards requirements for vitamin A in wheat flour. However, recognizing that the national standards are for the production level, and with due consideration for differences between production and retail level, we used a lower cutoff (0.3 mg/kg) and found that 11 out of 14 brands (78 percent) met the minimum acceptable vitamin A requirement. The absence of any quantifiable amount of vitamin A in some flour samples indicated that the food processors are using a premix formulation that does not contain vitamin A. Fifteen15 of the 29 (52%) brands analyzed quantitatively for zinc passed. The average zinc concentration in the 15 wheat flour brands was 51.3 mg/kg (range: 36.1–76.8, 95% CI: 45.8–58.0 mg/kg). See Table 6 for details.

Table 6. Concentration of Total Iron, Zinc, and Vitamin A in Wheat Flour

Wheat Flour Food Brands	Acceptable Range of added Total Iron [>=21 mg/kg]	Acceptable Range of added Zinc [33–65 mg/kg]	Acceptable Range of added Vit A [0.3–1.4 mg/kg]	Remarks (Based on Standards and Micronutrients)
Angel Home Baking Flour	21.3	15.5	0.00	Failed for vit. A and zinc
Atta Mark 1 Stone Ground	55.3	69.2	0.43	Passed
Azam Fortified Home Baking Flour	42.1	50.6	0.33	Passed
Baba Lao Ngano Balaa	38.2	55.9	0.38	Passed
Blue Ribbon - Fortified Home Baking Wheat Flour	24.1	20.5	0.30	Failed for zinc
Drum Atta Fresh	28.8	48.0	0.00	Failed for vit. A
Drum Fortified Atta Wheat Flour	40.5	16.4	0.00	Failed for vit. A and zinc
Drum Fortified Home Baking Wheat Flour	36.9	23.6	0.31	Failed for zinc
Dunia Unga Safi Wa Ngano	41.9	52.6	0.50	Passed
Everyday Fortified Atta Flour	24.5	13.7	0.00	Failed for vit. A and zinc
Everyday Fortified Home Baking Flour	26.8	38.5	0.00	Failed for vit. A
Farina - Fortified Home Baking Wheat Flour	30.4	31.7	0.22	Failed for vit. A and zinc
Fortified Home Baking Wheat Flour-Horse Brand-Kaswa	50.7	36.1	0.43	Passed
Gold Medal Home Baking Wheat Flour	17.2	18.8	0.00	Failed for everything
Golden All Purpose Home Baking Flour	31.3	76.8	0.00	Failed for vit. A
Jiko Fortified Home Baking Wheat Flour	25.7	8.7	0.46	Failed for zinc
King Fortified Home Baking Flour	42.4	51.2	0.53	Passed
Modern Fortified Home Baking Wheat Flour	26.7	11.7	0.00	Failed for vit. A and zinc
Nano Home Baking Wheat Flour	36.0	57.8	0.00	Failed for vit. A
Nile Fortified Home Baking Wheat Flour	22.8	13.8	0.00	Failed for vit. A and zinc
Nile Fortified Home Baking Wheat Flour-Unga Safi Wa Ngano	32.0	10.4	0.00	Failed for vit. A and zinc
Pembe All Purpose Flour	43.0	58.0	0.51	Passed
Pembe Multipurpose Home Baking Flour	28.7	8.9	0.00	Failed for vit. A and zinc

Pembe Premium All Purpose Home Baking Flour	34.0	30.3	0.26	Failed for vit. A and zinc
Safy – Home baking Wheat flour	27.4	52.8	0.00	Failed for vit. A
Supreme Fortified Home baking Flour (All Purpose Flour)	33.4	39.8	0.49	Passed
Tembo - Fortified Home Baking Flour	24.8	13.5	0.00	Failed for vit. A and zinc
Unga EXE All Purpose Fortified Home Baking Flour	21.4	44.9	0.00	Failed for vit. A
Unga EXE Self Raising Fortified Wheat Flour	33.1	46.4	0.29	Failed for vit. A

*Imported brands

4.0 Discussion

The market study collected 216 fortified food samples, which included 49 salt samples from 24 brands, 75 edible oil samples from 17 brands, 11 samples of vegetable fat from three brands, 66 wheat samples from 29 brands, and 15 maize flour samples from eight brands. The qualitative test results showed that all the edible fat samples and 91 percent of the edible oil samples contained vitamin A; 98 percent of salt samples contained iodine; 60 percent of wheat flour samples contained iron, and 44 percent contained vitamin A; and 73 percent of maize flour samples contained iron and 47 percent contained vitamin A. The qualitative test for zinc did not discriminate of fortified from non-fortified foods, and therefore those results were not useful in this study.

We assessed the concentration of vitamin A, iodine, iron, and zinc in the relevant food vehicles and assessed whether the concentration against two criteria—one whether the concentration was above the minimum cutoff of the Uganda national standards for micronutrients at the production level, and another where we lowered the minimum cutoff below the national standard, with due consideration that these cutoffs at the production level are being imposed at the retail level. We found that the average concentration of iodine in the salt brands was 28.3 mg/kg with 54 percent of the brands meeting the minimum level (30 mg/kg) of Ugandan cutoffs and 75 percent meeting our more tolerant threshold of 20 mg/kg. The average concentration of vitamin A for edible oils and edible fats was 20.1 and 21.6 µg retinol activity equivalents/kg. 61 percent of the edible oil brands met the minimum level (20 µg retinol activity equivalents/kg) of the Uganda standards and 89 percent met our more tolerant standards (15 µg retinol activity equivalents/kg). All of the edible fat brands met both the standards. The average vitamin A concentration in the three maize brands was 0.5 mg/ kg. 13 percent of maize flour brands met the minimum level (0.5 mg/kg) of the Uganda standards and 38 percent met our more tolerant standards (0.3 mg/kg). The average vitamin A concentration in wheat flour was 0.39 mg/ kg. 10 percent of wheat flour brands met the minimum level (0.5 mg/kg) of the Uganda standards and 38 percent met our more tolerant standards (0.3 mg/kg). The average zinc concentration in maize and wheat flour brands was 25.3 and 35 mg/ kg. 50 and 52 percent of maize and wheat flour brands, respectively, met the minimum level (33 mg/kg) of the Uganda standards. The average iron concentration in the maize and wheat flour brands was 34.4 and 32.1 mg/kg, respectively. 63 percent of maize and 97 percent of wheat flour brands met the Uganda national standards requirement for total iron in flour. The absence of iron in the maize and wheat brands for the iron spot test and yet detected during a quantitative test need further investigation into the premix, because they may be using a premix whose source of iron is FeNaEDTA or reduced iron or they are high extraction flours. Overall, based on the three micronutrients tested in maize and wheat flour brands, only 38 percent (3/8) of maize brands and 28 percent (8/29) of wheat brands conformed to the minimum standards for all micronutrients.

5.0 Recommendations

Based on the above results, we recommend the following:

1. The market surveillance studies need to be conducted at specified intervals, possibly annually, to assess the availability and concentration of micronutrients in fortified food vehicles at the retail level.
2. The market surveillance results are critical to filling the gaps in the fortification data value chain, which extends from importation to production, and then to wholesale and retail,
3. Household-level surveys like the UNPS may complement data from market surveillance and enforcement and monitoring activities undertaken by regulatory bodies like Uganda National Bureau of Standards (UNBS) for effective monitoring of the program.
4. In the iodized salt program, the levels of iodine in salt, whether imported or locally manufactured are sufficient to maintain optimal iodine status, as seen in biomarker surveys carried out (UNPS). Key actions include continued monitoring at the importation, production, and retail level to maintain program success.
5. In edible oil and fat fortification, the level of vitamin A has contributed to the low levels of vitamin A deficiency in Uganda, as reported in biomarker surveys carried out (UNPS). Key actions include continued monitoring at the production and retail level to maintain program success, and technical assistance to manufacturing units that are unable to meet the production standards or our more tolerant retail level standards for vitamin A level.
6. Wheat flour fortification depends on large-scale industries that are more centralized, and have the capacity to carry out production-level quality control and assurance, and make changes in to the production process to be able to adjust the level of micronutrients. Market surveillance studies and social audits will provide signals to the production units from the retail level for them to make these changes.
7. Maize flour production is fragmented with almost all of the production being carried out by small- and medium-scale industries with production capacities below 20 metric tons of flour per day. This will make it challenging to allow for fine tuning of production processes to ensure that sufficient quantities of premixes are added during the production of maize flour and for regulatory agencies to monitor the level of micronutrients at every production facility. Market surveillance or social audit studies will be useful to monitor micronutrient levels at the retail level but they must be supported by a system that can link these findings to the manufacturing units.
8. The results indicate that some millers are possibly using nonstandard premixes, given the absence of vitamin A and zinc from some samples of wheat flour. These results align with issues raised at national forums by producers who note their challenges in premix dosing, quality, and formulation and lack of regulation of premix from supplier to producer, among others. The following are proposed recommendations to address these premix challenges:

- Regulatory bodies need to provide a verification/prequalified list of suppliers of fortificants/premixes to industries to ensure quality.
- Strengthen access to test fortificants/premixes, which is critical to ascertaining the quality of imported premixes—other than relying on the supplier's certificate of conformity; invest in training on proper handling and storage to address noncompliance with standards.
- Where appropriate, premix supply systems should be put in place (including transparent procurement mechanisms based on a competitive tendering process) so premix suppliers are

forced to compete with one another on quality and price, thereby preventing premix suppliers from monopolizing the supply of micronutrient fortification in a given context (Garrett, Luthringer, and Mkambula 2016; Guinot et al. 2012).

6.0 Conclusion

Based on the results of our study, we suggest that these types of market surveillance studies are carried out at regular intervals, potentially on an annual basis, to assess the availability and concentration of micronutrients in fortified food vehicles at the retail level. The results will also fill in the gaps in the fortification data value chain at the production level, and may complement data from enforcement and monitoring activities undertaken by regulatory bodies like UNBS, and data from household surveys like the UNPS. Strengthening regulation efforts to ensure fortificant/premix quality is essential for an effective food fortification program.

The market surveillance report will be shared with relevant stakeholders to influence policy discussions, for regulatory bodies and industries to assess the root cause of the noncompliance, and for advocacy by civil society to influence and demand conformity at all levels. Based on the results of the market surveillance study, we find that the food fortification program in Uganda with the four food vehicles (salt, oil and vegetable fat, wheat flour, and maize flour) is working well and it has made significant contributions to the elimination of iodine and vitamin A deficiencies. It continues to provide iodine, vitamin A, iron and zinc to the population to supplement their food dietary intake, and modifications to the monitoring and enforcement regime by regulatory agencies will improve the efficiency of the delivery of these micronutrients to eliminate "hidden hunger".

7.0 References

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Annex 1. Data Collection Tools/Materials

Sample collection form-This sample collection form is adapted from the ECSA-HC Manual for commercial inspection of fortified foods and the Fortification assessment coverage toolkit manual

Region					Food Vehicle						Questionnaire #
Subregion					District						
Market Outlet/place					Labeling Information						Coordinates Y/N
Date	Retail outlet type	Brand name with product description	unique sample code	Labeled as fortified/f-logo/nutrient specification	Producer name	Batch Number	Production date	Expiry/Best before date	Original packaging type	Original packaging size	
Checked by							Date				

[a] Mention of added micronutrients or includes the F-Logo or the word fortified

Annex 2. Food Fortification Standards Cutoff Limits and Test Method

Nutrient	Fortificant	Fortified Wheat Flour Limits mg/kg	Fortified Milled Maize (Corn) Products Limits mg/kg			Test method
		Min.	Max.	Min.	Max.	
Vitamin Aa	Vitamin A (Retinyl) palmitate, spray-dried or equivalent, 75 000 µg RE/gb (7.5 % retinol), min.	0.5	1.4	0.5	1.4	AOAC 2001.13
Zinc	Zinc oxide, 80 %, min.	40	80	33	65	AOAC 2011.14
Total iron	Total iron	20	NA	21	NA	AOAC 944.02
Requirements for Vitamin A in fortified edible fats and oils						
Vitamin A	Vitamin A (Retinyl) palmitate	20	40			AOAC 2001.13
Required levels of iodine in food grade salt						
Iodine	Potassium iodide: Recommended factory level 40±5	30	60			AOAC 935.14

Source: UNBS Standards Catalogue

Annex 3. Detailed Laboratory Analytical Methods

METHOD	PRINCIPLE
Determination of Iodine in Edible Salt	
Determination of Iodine (Qualitative)	The method is used for detecting the presence of iodine based on the generation of iodine and triiodide. Iodine in the salt sample is dissolved in a sulphuric acid solution and then a solution of potassium iodide (KI) and starch is added. The iodate from salt reacts with iodide (I-) to form iodine (I2) and triiodide (I3 -), which is very soluble in water. A yellow color is formed first and, when the starch solution is added, then a blue-colored complex is formed between starch and triiodide. The intensity of the blue color provides a general approximation of the amount of iodine in the solution, but many factors such as the alkalinity of the salt and aging of the starch solution may modify the intensity, tonality, and stability of the color.
Titrimetric Determination of Iodine (Quantitative) Reference: AOAC Official Methods of Analysis. 1984. Section 33, 147.	This iodometric titrimetric method is used to determine the quantifiable amount of iodine in salt fortified with potassium iodate. Acid is added into a salt solution to make it slightly acidic followed by the addition of excess KI. The iodate in the salt reacts with iodide (I -) to form iodine (I2) and triiodide (I3-), which dissolves in water to form a yellowish solution. When a starch solution is added, a blue-colored complex between triiodide and starch is formed. The amount of iodine in the solution is determined by titration with a standard thiosulfate solution, which removes the iodine and as a result, the blue color disappears. The endpoint is visually determined by the disappearance of the blue color from the solution when no more iodine is present.
Determination of Iron in Flours (Wheat/Maize)	
Qualitative method to determine Iron in flour (Iron Spot Test) Reference: AACC Method 40-40. Iron-Qualitative Method	Ferric iron, in an acidic medium, reacts with a solution of potassium thiocyanate (KSCN) to form an insoluble red pigment. Other types of iron, such as ferrous iron and elemental iron can also react in a similar manner once they are oxidized to the ferric form using hydrogen peroxide. Here, it is important to state that the presence of electrolytic or reduced iron may be determined visually when a magnet is inserted into flour slurry. After stirring the slurry for ten minutes, iron particles stick to the magnet
Quantitative spectrophotometric method for determining total iron in flour. Reference AOAC. Official Methods 944.02	The determination of total iron in foods usually includes the total combustion of organic materials leaving only the ash, which contains the mineral part of foods. This process transforms all iron present to the oxidized ferric form (Fe3+). A solution of the ash is prepared using hydrochloric acid and the iron (III) is reduced to iron (II) using hydroxylamine hydrochloride. The ferrous ion (Fe2+) can be determined spectrophotometrically by forming colored complexes using several chromogens that interact with iron (Fe2+) such as 1,10-phenanthroline.H2O; bathophenanthroline, (a sulphonic salt of 4,7- diphenyl–1,10 phenanthrolyne); α,α - dipyridile (2,2' bipyridine); or ferrozyne (acid[3–(2-pyridyle)- 5,6–bis-(4- phenylsulphonic)–1,2,4-triazine). The color reaction has to be performed under pH-controlled conditions suitable for the chromogen. In order to reduce the competition by hydronium ions (H3O+) for the ligand, a solution of 2 M sodium acetate is added.
Determination of Zinc in Flours	
Quantitative spectrophotometric method for determining zinc in flours	The test portions are dried and then ashed at 550^{o}c in a muffle furnace for 4-6 hours. The ash of the food sample obtained is dissolved in 1M HCl and HNO_3 and then analyzed using the Atomic Absorption Spectrophotometer (AAS). Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in food. Ash content represents the total mineral content in foods. The absorbance is read using the Atomic Absorption Spectrophotometer (AAS) as per AAS operating procedure after which the zinc content is calculated.
Determination of Vitamin A in Flours	

METHOD	PRINCIPLE
Qualitative determination of Vitamin A in Flours	Vitamin A (Retinyl palmitate) used for fortifying flours is extracted into organic solvents after mixing the flour with water and 2-propanol. The organic solution containing vitamin A is then reacted with chromogenic solutions to produce a blue solution. The limitation of the traditional methods is attributed to two main reasons:(1) the amount of vitamin A added to flour is low and hence the blue color is pale, and (2) the color produced is transient and all decisions should be done swiftly within 10-15 seconds of mixing the vitamin A extract with the chromogenic solution. Based on results obtained in the laboratory, solutions giving a blue or light blue color will be reported as positive, with a concentration above 0.5 mg/kg. The development of a blue color indicates the presence of vitamin A in the flour and the intensity of the color is directly proportional to the concentration of vitamin A in the sample.
Quantitative determination of vitamin A by High-Performance Liquid Chromatography (HPLC) References: Horwitz W and GW Latimer (Eds.). AOAC Official Method 2001.13. Vitamin A (Retinol) in Foods. Vitamins and Other Nutrients. Chapter 45, p.53-56. Official Methods of Analysis of AOAC International. 18thed, Revision 2, 2007. Maryland.	Standards and samples are saponified in basic ethanol-water solution, neutralized, and diluted. This process converts fats to fatty acids, and retinyl esters to retinol and the corresponding fatty acids. Extract clean-up is carried out with a C18 cartridge and vitamin A is concentrated eluting with a smaller volume of isopropanol than the aliquot taken to clean. Retinol is quantified in an LC system, using UV detection at 326 nm. Concentration is calculated by comparison of peak heights or peak areas of retinol in test samples with those of standards.
Determination of vitamin A in fortified Edible Oil & Fat	
Semi-quantitative method for determining vitamin A in fortified edible oil and fat	The method described is based on the formation of anhydro-retinol when retinol or its esters react with a chromogenic solution made by dissolving trifluoroacetic acid (TFA) in dichloromethane (DCM). A blue complex is formed and the intensity of the color is proportional to the amount of retinol which can be measured semi-quantitatively by visual comparison against a reference scale of standard copper sulfate solutions. The blue color is transient, so the comparison should be done within 10 seconds of adding the reagent. Other compounds can replace TFA, such as trichloroacetic acid (TCA) and antimony trichloride (Carr Price solution) (see section F). However, TFA has proved to be easier to handle and does not run cloudy due to moisture absorption as does TCA under humid conditions. DCM is preferred but other solvents such as hexane or chloroform may also be used.
Quantitative spectrophotometric method for determining vitamin A in fortified edible oils and fats Reference: Kambagar, T & Fawzi, A.B. (1978). Spectrophotometric Determination of Vitamin A in fortified edible oils and fats and Fats. J Assoc Off Anal Chem. 61(3):753-755.	The method is applicable to fortified edible oils and fats fortified with vitamin A in the form of retinyl palmitate or retinyl acetate, and it is based on absorbance of retinol within the UV-VIS region. Retinol and its esters absorb UV radiation with a maximum of 325 nm. Retinyl esters in the fortified edible oils and fats are determined by diluting the fortified edible oil or fat in organic solvents such as dichloromethane, chloroform or hexane, followed by reading the absorbance of the solution at 325 nm. The concentration of retinol is estimated by dividing the absorbance with the extinction coefficient of retinol and its esters in the different solvents. Other substances naturally present in fortified edible oils and fats such as carotenoids absorb close to 325 nm and so absorbance must be corrected for a blank absorbance of the specific fortified edible oil/fat using unfortified edible oil/fat from the same batch. Another option is to read the absorbance of the sample solution before and after exposure to ultraviolet irradiation. The difference between the two readings is associated with retinyl ester which is destroyed by the UV-irradiation b) Alternative procedure: Irradiation with UV light in the irradiation chamber Place about 2.5 mL of the diluted samples into a 10 mm x 75 mm glass test tube transparent to UV light and close it with a cap resistant to dichloromethane or hexane.

METHOD	PRINCIPLE
	Irradiate the tubes in the irradiation chamber for 35 minutes (or the time required according to the performance of the irradiation chamber Adjust the zero of the spectrophotometers with the solvent. Read the absorbance of the irradiated and unirradiated solutions at 325 nm in 1 cm light path quartz cuvettes. Calculate vitamin A concentration with the following equation: **where** Abscorrected is: Abs corrected = (Abs unirradiated sample)–(Abs irradiated sample).

Annex 4: Available Industries and Brands Labeled as Fortified in the Market

Food Vehicle	Producer	Brand
Edible Fats	Bidco (U) Ltd	Cowboy
		Kimbo
	Mukwano	Tamu
Edible Fats Total		**3**
Edible Oils	Bajaber Industries Ltd	Pembe Oil - Fortified Refined Edible Vegetable Oil
	Bidco (U) Ltd	Fortune Butto
		Fortune Gold - Fortified Edible Vegetable Oil
		Fortune Sunflower Oil
		Golden Fry - Fortified Edible Vegetable Oil
	Mmp Agro Industries	Soya Premium Refined Fortified Edible Vegetable Cooking Oil
		Sunvita - Fortified Refined Sunflower Oil
	Mount Meru Industries	Star Goldy - Fortified Blended & Refined Vegetable Oil
	Mukwano	Mukwano Fortified Blended Edible Vegetable Oil Refined Oil
		Roki Fortified Blended Edible Vegetable Oil Refined Oil
		Soyseed Fortified Edible Soyabean Oil
		Sunseed Fortified Edible Sunflower Oil Refined Oil
	Nile Agro Industries Ltd	Modern Refined & Blended Fortified Vegetable Cooking Oil
		Nile Fortified Edible Cooking Oil
	Tasco Industries Ltd	Star Fry
	Vegol Ltd	Best Fry
		Best Fry Siika
Edible Oils Total		**17**
Maize flour	Afro-Kai Limited	Fortified Maize Flour - Meal Life
	Aponye Uganda Limited	Ugali
	Grainpulse Limited	Jjimu Fortified Maize Flour
	Kabana Grain Millers Limited	Kob Posho

Food Vehicle	Producer	Brand
	Maganjo Grain Millers Limited	Maganjo Maize Flour
	Mandela Millers Limited	Supreme Fortified Maize Flour
	Pan Afric Impex (U) Limited	Joha
	Sma Millers (U) Limited	King Fortified Maize Flour
Maize flour Total		**8**
Salt	Sourcing Ltd	Platinum Himalayan Pink Fortified Salt
	American Garden Company New York	American Garden (Double Refined)
	American Kitchen Delaware	American Kitchen Iodised Salt
	Balaji Chemfood (India)	Refined Free Flow Iodized Salt
	Crystal Line K-Limited (Kenya)	Habari Salt
		Kaysalt (Tripple Refine Free Flow)
		Kaysalt Premium
	General Food Processing Industries Llc (Dubai)	Double Refined Salt Iodized
	Herbal Salt Plus Limited	Table Salt Plus
	Ken Salt Limited (Kenya)	Bahari Salt
		Kensalt (Premium Sea Salt) Pearl Iodated Edible Sea Salt
	Malindi Salt Works Limited (Kenya)	Malindi Salt
		Sun Salt Tembo Pure Refined
	Manufactured By Oswal Extrusion Limited	I-Shakti Iodised Salt
	Neelkanth Salt Limited (Tanzania)	Neel Premium
	Packaged By Carebos Limited South Africa	Carebos Iodated Table Salt
	Packed By Cable Uganda Trust Limited	Table Organic
	Packed By: Isf, Uae-Dubai Uae	Pure Refined Salt
	Repacked & Distributed Zee Packaging Limited (Uganda)	Double Cock Salt
		Naturally Salty
	Tata Chemicals Limited (India)	Tata Salt
	The Kampala Industries And Infrastructure Development Limited	Kampala Salt
Salt Total		**24**

Food Vehicle	Producer	Brand
Wheat Flour	Ahmed Raza Foods Industries Limited	Everyday Fortified Atta Flour
		Everyday Fortified Home Baking Flour
	Alfil Millers (U) Limited	Tembo - Fortified Home Baking Flour
	Bajaber Industries Ltd	Pembe Multipurpose Home Baking Flour
		Pembe Premium All-Purpose Home Baking Flour
	Bajaber Millers Limited	Farina - Fortified Home Baking Wheat Flour
	Bakhresa Grain Milling (Uganda) Limited	Azam Fortified Home Baking Flour
	Engaano Millers Ltd - Jinja	Drum Atta Fresh
		Drum Fortified Atta Wheat Flour
		Drum Fortified Home Baking Wheat Flour
	Family Commodities	Angel Home Baking Flour
	Golden Harvest Mills (Kenya)	Golden All Purpose Home Baking Flour
	Kengrow Industries Limited	Gold Medal Home Baking Wheat Flour
	King Millers Limited	Nano Home Baking Wheat Flour
	Kitui Flour Mills (Kenya)	Baba Lao Ngano Balaa
	Maganjo Grain Millers Limited	Jiko Fortified Home Baking Wheat Flour
	Mandela Millers Limited	Supreme Fortified Home Baking Flour (All Purpose Flour)
	Master Grain Milling Limited	Blue Ribbon - Fortified Home Baking Wheat Flour
	Mt. Elgon Millers Limited	Safy - Home Baking Wheat Flour
	Nile Agro Industries Ltd	Modern Fortified Home Baking Wheat Flour
		Nile Fortified Home Baking Wheat Flour
		Nile Fortified Home Baking Wheat Flour-Unga Safi Wa Ngano
	Ntake Bakery And Company Limited	Fortified Home Baking Wheat Flour- Horse Brand-Kaswa
	Pembe Flour Limited (Kenya)	Dunia Unga Safi Wa Ngano
		Pembe All Purpose Flour
	Sma Millers (U) Limited	King Fortified Home Baking Flour
	Spice World Limited (Kenya)	Atta Mark I Stone Ground
	Unga Limited Nairobi (Kenya)	Unga Exe All Purpose Fortified Home Baking Flour
		Unga Exe Self Raising Fortified Wheat Flour
Wheat Flour Total		**29**

Annex 5. Qualitative Results of Food Samples by Brands for Edible, Salt, Fat and Oil

Food Vehicle	Name of Producer	Product Brand	# samples tested negative	# samples tested positive
Edible Fat [Vitamin A]	Bidco (U) Ltd	Cowboy		5
		Kimbo		5
	Mukwano Industries (U) Ltd	Tamu		1
Edible Oil [Vitamin A]	Bajaber Industries Ltd	Pembe Oil - Fortified Refined Edible Vegetable Oil	4	1
	Bidco (U) Ltd	Fortune Butto		5
		Fortune Gold - Fortified Edible Vegetable Oil		5
		Fortune Sunflower Oil		5
		Golden Fry - Fortified Edible Vegetable Oil		4
	MMP Agro Industries	Soya Premium Refined Fortified Edible Vegetable Cooking Oil		2
		Sunvita - Fortified Refined Sunflower Oil		5
	Mount Meru Industies	Star Goldy - Fortified Blended & Refined Vegetable Oil	1	4
	Nile Agro Industries Ltd	Modern Refined & Blended Fortified Vegetable Cooking Oil		1
		Nile Fortified Edible Cooking Oil		6
	TASCO Industries Ltd	Star Fry		5
	Vegol Ltd	Best Fry		2
		Best Fry Siika		5
	Mukwano Industries (U) Ltd	Mukwano Fortified Blended Edible Vegetable Refined Oil		4
		Roki Fortified Blended Edible Vegetable Refined Oil		5
		Soyseed Fortified Edible Soyabean Oil	2	4
		Sunseed Fortified Edible Sunflower Oil Refined Oil		5
	Sourcing Ltd	Platinum Himalayan Pink Fortified Salt**		3

Food Vehicle	Name of Producer	Product Brand	# samples tested negative	# samples tested positive
Edible Salt [Iodine]	American Garden Company Newyork	American Garden (Double Refined)	1	
	American Kitchen Delaware	American Kitchen Iodised Salt		1
	Balaji Chemfood (India)	Refined Free Flow Iodized Salt		3
	Crystal Line K-Limited (Kenya)	Habari Salt		5
		Kaysalt (Tripple Refine Free Flow)		2
		Kaysalt Premium		1
	General Food Processing Industries LLC (Dubai)	Double Refined Salt Iodized**		4
	Herbal Salt Plus Limited	Table Salt Plus**		2
	Ken Salt Limited (Kenya)	Bahari Salt		4
		Kensalt (Premium Sea Salt)		1
		Pearl Iodated Edible Sea Salt		1
	Malindi Salt Works Limited (Kenya)	Malindi Salt		2
		Sun Salt		2
		Tembo Pure Refined		1
	Manufactuered By Oswal Extrusion Limited	I-Shakti Iodised Salt		1
	Neelkanth Salt Limited (Tanzania)	Neel Premium		1
	Packaged By Carebos Limited South Africa	Carebos Iodated Table Salt		1
	Packed By Cable Uganda Trust Limited	Table Organic**		1
	Packed By: ISF, UAE-Dubai UAE	Pure Refined Salt		1
	Repacked & Distributed Zee Packaging Limited (Uganda)	Double Cock Salt		3
		Naturally Salty**		1
	TATA Chemicals Limited (India)	Tata Salt		4
	The Kampala Industries and Infrastructure Development Limited	Kampala Salt*		3

*Locally produced ** Locally repackaged

Annex 6: Qualitative Tests Results of Food Samples by Brands for Wheat and Maize Flour

Food Vehicle	Name of Producer	Product Brand	Iron		Vitamin A	
			Negative	Positive	Negative	Positive
Maize flour	Afro-Kai Limited	Fortified Maize Flour - Meal Life		1		1
	Aponye Uganda Limited	Ugali	2		2	
	Grainpulse Limited	Jjimu Fortified Maize Flour		1		1
	Kabana Grain Millers Limited	Kob Posho		2	2	
	Maganjo Grain Millers Limited	Maganjo Maize Flour	1	1	2	
	Mandela Millers Limited	Supreme Fortified Maize Flour		5		5
	Pan Afric Impex (U) Limited	Joha		1	1	
	SMA Millers (U) Limited	King Fortified Maize Flour	1		1	
Wheat flour	Ahmed Raza Foods Industries Limited	Everyday Fortified Atta Flour	1		1	
		Everyday Fortified Home Baking Flour		2	2	
	Alfil Millers (U) Limited	Tembo - Fortified Home Baking Flour	1		1	
	Bajaber Industries Ltd	Pembe Multipurpose Home Baking Flour	2	1	3	
		Pembe Premium All Purpose Home Baking Flour		2		2
	Bajaber Millers Limited	Farina - Fortified Home Baking Wheat Flour		2		2
	Bakhresa Grain Milling (Uganda) Limited	Azam Fortified Home Baking Flour		5		5
	Engaano Millers Ltd - Jinja	Drum Atta Fresh	1		1	
		Drum Fortified Atta Wheat Flour	1	1	2	
		Drum Fortified Home Baking Wheat Flour	1	4	2	3
	Family Commodities	Angel Home Baking Flour	1		1	
	Golden Harvest Mills (Kenya)	Golden All Purpose Home Baking Flour*		1	1	
	Kengrow Industries Limited	Gold Medal Home Baking Wheat Flour	3		3	
	King Millers Limited	Nano Home Baking Wheat Flour	2	1	3	

Food Vehicle	Name of Producer	Product Brand	Iron		Vitamin A	
			Negative	Positive	Negative	Positive
	Kitui Flour Mills (Kenya)	Baba Lao Ngano Balaa*		1		1
	Maganjo Grain Millers Limited	Jiko Fortified Home Baking Wheat Flour	3	1	3	1
	Mandela Millers Limited	Supreme Fortified Homebaking Flour (All Pupose Flour)		5	2	3
	Master Grain Milling Limited	Blue Ribbon - Fortified Home Baking Wheat Flour		4	2	2
	Mt. Elgon Millers Limited	Safy - Homebaking Wheatflour		1	1	
	Nile Agro Industries Ltd	Modern Fortified Home Baking Wheat Flour	2		2	
		Nile Fortified Home Baking Wheat Flour	3		3	
		Nile Fortified Home Baking Wheat Flour-Unga Safi Wa Ngano	3		3	
	Ntake Bakery and Company Limited	Fortified Home Baking Wheat Flour- Horse Brand-Kaswa	2	2		4
	Pembe Flour Limited (Kenya)	Dunia Unga Safi Wa Ngano*		1		1
		Pembe All Purpose Flour*		1		1
	SMA Millers (U) Limited	King Fortified Home Baking Flour		1		1
	Spice World Limited (Kenya)	Atta Mark 1 Stone Ground*		1		1
	UNGA Limited Nairobi (Kenya)	Unga Exe Self Raising Fortified Wheat Flour*		2		2
		Unga Exe All Purpose Fortified Home Baking Flour*		1	1	

Key:

(Green = Present/positive, and Red =Absent/negative) for the respective micronutrient/mineral qualitatively tested as per the standard cut-off limits.
*Imported brands

Annex 7. Micronutrient Content in all Food Samples

Food Vehicle	Producer	Product Brand	Iodine in salt 30-60 mg/kg	Vit A in Oil & fat 20-40 mg/kg	VIT A in flour 0-3-1.4 mg/kg	Iron in Flour >=21 mg/kg	Zinc in flour 33-65 mg/kg
Edible Fats	Bidco (U) Ltd	Cowboy		21.8			
		Kimbo		19.9			
	Mukwano Industries (U) Ltd	Tamu		22.9			
Edible Oils	Bajaber Industries Ltd	Pembe Oil - Fortified Refined Edible Vegetable Oil		22.9			
	Bidco (U) Ltd	Fortune Butto		25.0			
		Fortune Gold - Fortified Edible Vegetable Oil		26.2			
		Fortune Sunflower Oil		20.6			
		Golden Fry - Fortified Edible Vegetable Oil		17.8			
	MMP Agro Industries	Soya Premium Refined Fortified Edible Vegetable Cooking Oil		11.4			
		Sunvita - Fortified Refined Sunflower Oil		20.4			
	Mount Meru Industies	Star Goldy - Fortified Blended & Refined Vegetable Oil		24.5			
	Mukwano Industries (U) Ltd	Mukwano Fortified Blended Edible Vegetable Refined Oil		21.7			
		Roki Fortified Blended Edible Vegetable Refined Oil		18.3			
		Soyseed Fortified Edible Soyabean Oil		23.7			
		Sunseed Fortified Edible Sunflower Refined Oil		20.5			
	Nile Agro Industries Ltd	Modern Refined & Blended Fortified Vegetable Cooking Oil		16.9			
		Nile Fortified Edible Cooking Oil		16.6			
	TASCO Industries Ltd	Star Fry		20.4			
	Vegol Ltd	Best Fry		12.5			
		Best Fry Siika		22.1			
Maize flour	Afro-Kai Limited	Fortified Maize Flour - Meal Life			0.45	76.1	53.3

Food Vehicle	Producer	Product Brand	Iodine in salt 30-60 mg/kg	Vit A in Oil & fat 20-40 mg/kg	VIT A in flour 0-3-1.4 mg/kg	Iron in Flour >=21 mg/kg	Zinc in flour 33-65 mg/kg
	Aponye Uganda Limited	Ugali			0.00	4.8	1.3
	Grainpulse Limited	Jjimu Fortified Maize Flour			0.50	55.5	45.2
	Kabana Grain Millers Limited	Kob Posho			0.00	56.4	41.4
	Maganjo Grain Millers Limited	Maganjo Maize Flour			0.00	13.3	6.2
	Mandela Millers Limited	Supreme Fortified Maize Flour			0.46	21.3	44.1
	Pan Afric Impex (U) Limited	Joha			0.00	43.4	10.0
	SMA Millers (U) Limited	King Fortified Maize Flour			0.00	4.7	0.9
Table Salt	Sourcing Ltd	Platinum Himalayan Pink Fortified Salt^	37.1				
	American Garden Company Newyork	American Garden (Double Refined)	2.1				
	American Kitchen Delaware	American Kitchen Iodised Salt	18.0				
	Balaji Chemfood (India)	Refined Free Flow Iodized Salt	10.6				
	Crystal Line K-Limited (Kenya)	Habari Salt	35.5				
		Kaysalt (Tripple Refine Free Flow)	29.2				
		Kaysalt Premium	29.2				
	General Food Processing Industries LLC (Dubai)	Double Refined Salt Iodized^	32.9				
	Herbal Salt Plus Limited	Table Salt Plus^	8.5				
	Ken Salt Limited (Kenya)	Bahari Salt	38.2				
		Kensalt (Premium Sea Salt)	11.7				
		Pearl Iodated Edible Sea Salt	39.3				
	Malindi Salt Works Limited (Kenya)	Malindi Salt	31.8				
		Sun Salt	43.5				
		Tembo Pure Refined	37.7				
	Manufactuered By Oswal Extrusion Limited	I-Shakti Iodised Salt	23.3				
	Neelkanth Salt Limited (Tanzania)	Neel Premium	32.9				

Food Vehicle	Producer	Product Brand	Iodine in salt 30-60 mg/kg	Vit A in Oil & fat 20-40 mg/kg	VIT A in flour 0-3-1.4 mg/kg	Iron in Flour >=21 mg/kg	Zinc in flour 33-65 mg/kg
	Packaged By Carebos Limited South Africa	Carebos Iodated Table Salt	38.2				
	Packed By Cable Uganda Trust Limited	Table Organic^	5.3				
	Packed By: ISF, UAE-Dubai UAE	Pure Refined Salt	32.4				
	Repacked & Distributed Zee Packaging Limited (Uganda)	Double Cock Salt	41.4				
		Naturally Salty^	24.9				
	TATA Chemicals Limited (India)	Tata Salt	22.3				
	The Kampala Industries and Infrastructure Development Limited	Kampala Salt^^	52.0				
Wheat Flour	Ahmed Raza Foods Industries Limited	Everyday Fortified Atta Flour			0.00	24.5	13.7
		Everyday Fortified Home Baking Flour			0.00	26.8	38.5
	Alfil Millers (U) Limited	Tembo - Fortified Home Baking Flour			0.00	24.8	13.5
	Bajaber Industries Ltd	Pembe Multipurpose Home Baking Flour			0.00	28.7	8.9
		Pembe Premium All Purpose Home Baking Flour			0.26	34.0	30.3
	Bajaber Millers Limited	Farina - Fortified Home Baking Wheat Flour			0.22	30.4	31.7
	Bakhresa Grain Milling (Uganda) Limited	Azam Fortified Home Baking Flour			0.33	42.1	50.6
	Engaano Millers Ltd - Jinja	Drum Atta Fresh			0.00	28.8	48.0
		Drum Fortified Atta Wheat Flour			0.00	40.5	16.4
		Drum Fortified Home Baking Wheat Flour			0.31	36.9	23.6
	Family Commodities	Angel Home Baking Flour			0.00	21.3	15.5
	Golden Harvest Mills (Kenya)	Golden All Purpose Home Baking Flour*			0.00	31.3	76.8
	Kengrow Industries Limited	Gold Medal Home Baking Wheat Flour			0.00	17.2	18.8
	King Millers Limited	Nano Home Baking Wheat Flour			0.00	36.0	57.8
	Kitui Flour Mills (Kenya)	Baba Lao Ngano Balaa*			0.38	38.2	55.9
	Maganjo Grain Millers Limited	Jiko Fortified Home Baking Wheat Flour			0.46	25.7	8.7
	Mandela Millers Limited	Supreme Fortified Home baking Flour (All Purpose Flour)			0.49	33.4	39.8

Food Vehicle	Producer	Product Brand	Iodine in salt 30-60 mg/kg	Vit A in Oil & fat 20-40 mg/kg	VIT A in flour 0-3-1.4 mg/kg	Iron in Flour >=21 mg/kg	Zinc in flour 33-65 mg/kg
	Master Grain Milling Limited	Blue Ribbon - Fortified Home Baking Wheat Flour			0.30	24.1	20.5
	Mt. Elgon Millers Limited	Safy – Home baking Wheat flour			0.00	27.4	52.8
	Nile Agro Industries Ltd	Modern Fortified Home Baking Wheat Flour			0.00	26.7	11.7
		Nile Fortified Home Baking Wheat Flour			0.00	22.8	13.8
		Nile Fortified Home Baking Wheat Flour-Unga Safi Wa Ngano			0.00	32.0	10.4
	Ntake Bakery and Company Limited	Fortified Home Baking Wheat Flour- Horse Brand-Kaswa			0.43	50.7	36.1
	Pembe Flour Limited (Kenya)	Dunia Unga Safi Wa Ngano*			0.50	41.9	52.6
		Pembe All Purpose Flour*			0.51	43.0	58.0
	SMA Millers (U) Limited	King Fortified Home Baking Flour			0.53	42.4	51.2
	Spice World Limited (Kenya)	Atta Mark 1 Stone Ground*			0.43	55.3	69.2
	UNGA Limited Nairobi (Kenya)	Unga EXE All Purpose Fortified Home Baking Flour*			0.00	21.4	44.9
		Unga EXE Self Raising Fortified Wheat Flour*			0.29	33.1	46.4

Key:

(Green = Pass, and red fail) for the respective micronutrient/mineral as per the standard cut-off limits.

*****Imported wheat brands

^Locally repackaged salt

^^Locally produced salt

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