MALAWI

IFPRI

STRATEGY SUPPORT PROGRAM | WORKING PAPER 28 | July 2019

Nutrient and mycotoxin content of commercially-sold premixed infant cereals in Malawi

Rachel Gilbert, Binita Subedi, Jessica Wallingford, Norbert Wilson and William A. Masters

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Fortified premixed cereals can help caregivers meet infants' nutrient needs, when used instead of traditional porridges to complement continued breastfeeding alongside the gradual introduction of nutrient-dense family foods from 6 to 24 months of age. Premixed cereals are widely used in nutrition assistance programs, but commercially-sold brands are often poorly regulated and labeled. This study provides the first combined assessment of nutrient levels and mycotoxins in samples of several commercially-sold premixed cereals (CPC) in Malawi, a country with high burdens of child malnutrition and an active market for CPCs.

A sample of CPCs available in markets in central and southern Malawi were tested for macronutrients, iron, and zinc as well as for the presence of aflatoxins and fumonisin. Test results were compared to both the values stated on the CPC labels and available standards. CPC samples largely met moisture, ash, and iron standards set by the Malawi Bureau of Standards (MBS), but only 35, 56, and 39 percent of samples were compliant with Malawi standards for zinc, protein, and fat, respectively. Most locally-made products had aflatoxin and fumonisin levels that exceeded national and international maximum allowable levels for infant foods. Labeled values deviated significantly from test results for all nutrients except protein and zinc.

Semi-structured interviews with stakeholders in Malawi highlighted challenges producers of CPCs face in meeting quality standards. Access to CPCs of high and uniform quality is hampered by poor market surveillance and standards enforcement, plus the cost of independent testing and other quality control measures. The introduction and enforcement of better standards for quality control and labeling of commercial complementary foods in Malawi could serve as a model for the other low- and middle-income countries facing similar issues.

Keywords: mycotoxins, quality assurance, Malawi, complementary feeding, infant cereal

ABBREVIATIONS

CF	Complementary Food
CPC	Commercially-sold premixed cereal
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organization of the United Nations
IARC	International Agency for Research on Cancer
IYCF	Infant and young child feeding
JECFA	Joint FAO/WHO Expert Committee on Food Additives
MBS	Malawi Bureau of Standards
NSO	National Statistical Office
SCP	Super Cereal Plus
WHO	World Health Organization

1 BACKGROUND AND MOTIVATION

1.1 Child Malnutrition and Feeding Practices in Malawi

Widespread child malnutrition persists in Malawi, with an estimated 37 percent of children under five classified as stunted in their growth in 2015/16 (NSO and ICF 2017). Stunting rates, defined as the fraction of children whose height for age is more than two standard deviations below the median of a healthy population, are higher in rural areas and among poorer households. However, even in the wealthiest quintile of households surveyed 24 percent of children were stunted (NSO and ICF 2017). Furthermore, evidence from 2016/17 suggests that the prevalence of wasting increased following two consecutive years of unfavorable climatic conditions for food crop production (IFPRI Malawi 2018).

Improving infant and young child feeding (IYCF) practices can help to address high levels of malnutrition. Linear growth faltering can begin in the womb and continue throughout childhood, but most faltering occurs during the crucial period when children transition from breastfeeding to consuming the family diet (Victora et al. 2010; Michaelsen et al. 2009). To avoid malnutrition, the WHO recommends that children be exclusively breastfed until they reach six months of age, at which point continued breastfeeding, water or other beverages should be accompanied by gradual introduction of increasingly diverse solid complementary foods (CFs) (WHO 2010).[1] CFs can be made from many kinds of ingredients, but must have sufficiently high nutrient density, bioavailability and digestibility to meet infant needs (EFSA Panel on Dietetic Products, Nutrition and Allergies 2009, 2013). CFs are generally softer and easier to swallow than family foods, and given more frequently than family meals until the child is at least two years old and able to chew and digest sufficient quantities of family foods (Victora et al. 2010; Joseph, Alavi, and Johnson 2017).

The provision of solid infant foods during the 6-24 month period is challenging not only because CFs must be made from more nutrient-dense ingredients and prepared more often than the family diet, but also because CFs must be delivered in a way that avoids exposing children to contaminants or infections (Stephenson et al. 2017; Dewey 2013; Victora et al. 2010). Nutritious and safe IYCF practices require higher levels of caregiver time and other resources than households typically provide to infants in low- and middle-income countries around the world, where actual feeding practices typically involve gradually introducing the same foods consumed by older children and adults (Choudhury, Headey, and Masters 2019). Nutritionally inadequate complementary feeding practices are also observed in Malawi, where less than two-thirds of infants under 6 months were exclusively breastfed, just a quarter of children ages 6–23 months met the WHO's minimum dietary diversity standards, and only 8 percent met the requirements for a minimum acceptable diet (NSO and ICF 2017).[2]

The foods that are typically used for IYCF in rural Malawi have been the subject of various previous studies (Vaahtera et al. 2001; Kalanda, Verhoeff, and Brabin 2006; Kuchenbecker et al. 2015). For example, *dawale* (an herbal infusion) and various maize-based porridges was associated with poor child growth in northern Malawi, in part because foods were contaminated or displaced more nutritious breastmilk (Kerr, Berti, and Chirwa 2007).[3] Qualitative research with mothers and caregivers in Dedza district of central Malawi documented that they fed infants a thin, watery porridge made from just maize because that is easy for the youngest children to swallow, and that adults and older children should be given priority in consumption of the family's other foods. In other settings, focus group discussions among caregivers who were mixing maize with legume flours for more nutrient-dense porridges revealed the use of shrivelled, discolored, and damaged groundnuts in those complementary foods

---

[1] Exclusive breastfeeding requires that infants receive only breast milk, including milk expressed or from a wet nurse, without receiving anything else (including water). The new definition allows a child to receive Oral Rehydration Salts (ORS), in addition to drops and syrups (vitamins, minerals, medicines) (WHO 2010).

[2] According to the DHS, minimum dietary diversity is defined as feeding the child food from at least four of the seven food groups. Minimum acceptable diet is calculated as the percentage of children age 6-23 months who had at least the minimum dietary diversity and the minimum meal frequency during the previous day.

[3] As defined by Kerr, Berti and Chirwa (2007) "*dawale* is a root that is cut up and added to water, which is boiled and then strained and given as water or added to porridge. Porridge includes *chinthipu* (made from maize and water), *mgaiwa* (made from fermented, unrefined maize), and *chinthuwe* (made from milk and maize flour)."

(Geresomo et al. 2017). Research from neighboring Zambia found that traditional maize-based complementary foods similar to Malawian *nsima* and mixed-flour porridge did not meet recommended nutrient levels for CFs and were contaminated with higher than recommended levels of aflatoxin (Alamu et al. 2018). As in other low-income settings (Choudhury, Headey, and Masters 2019), very few households use high-cost foods such as eggs, meat or even fruits and vegetables, and most prepared-at-home porridges use local starchy staples, sometimes combined with local leguminous grains. These may roasted and ground, germinated, fermented or otherwise prepared but tend to be bulky foods with low nutrient density and bioavailability of iron and zinc, and may be contaminated with pathogens or other harmful compounds like mycotoxins (Joseph, Alavi, and Johnson 2017; Abeshu, Lelisa, and Geleta 2016; Faber 2005; Gibson et al. 2003; Gibson, Ferguson, and Lehrfeld 1998).

Commercially-sold premixed cereals (CPC) can help address these deficiencies and meet infants' unique nutritional needs and feeding preferences (Gibson, Ferguson, and Lehrfeld 1998; Christian et al. 2015; Campbell et al. 2018). CPCs are commonly made from a cereal grain flour mixed with a leguminous grain (i.e. roasted soybeans) to add protein and fats, fortified with a micronutrient premix to further increase their nutrient density, and flavored to improve palatability. Skim milk powder or other additional ingredients may also be included, for both taste and nutrient density. Using consistent ingredient ratios can maintain uniform nutrient levels, and the resulting flour can be precooked and placed in sanitary packaging, so that adding water and briefly boiling the mixture results in a porridge that meets complementary food requirements with a low risk of contamination (Lutter and Dewey 2003).

Compared to CPCs, preparing CFs at home from raw ingredients can be more burdensome for caregivers. Research from a medium-income urban community in Lusaka, Zambia found that despite knowledge of optimal infant feeding practices, food costs and time availability were among the most important constraints on caregiver's actual IYCF practices (Owino et al. 2008). In such cases, high-quality CPC may improve children's nutrient intakes and ultimately nutritional outcomes (Collishaw 2017; Michaelsen et al. 2009).

In Malawi, consumption of the local CPC commonly known as *likuni phala* remains low, despite widely recognized potential of such cereals to increase weight and length gain and improve the nutrient status of young children (Olney et al. 2018; Panjwani and Heidkamp 2017; Phuka et al. 2008; Lartey et al. 1999). This is likely due to cost and availability constraints (Leyvraz et al. 2017; Dimaria et al. 2018), which in turn could be caused by lack of familiarity and trust in potentially low-cost local brands whose ingredient ratios are unknown. This stands in contrast to high prices charged for multinational brands whose quality is signaled by expensive advertising and quality assurance programs in their home country (Clark and Hobbs 2018). The most recent Malawi DHS found that only 5 percent of children between the ages of 6 and 35 months received *likuni phala* in the week prior to the survey, with a larger percentage of wealthier households reporting its consumption (NSO and ICF 2017). Less than 10 percent of children under 2 years old received any fortified baby foods in the 24 hours before the survey (NSO and ICF 2017). However, similar products are widely used for humanitarian purposes and development and school-feeding programs, often manufactured by the same companies who produce for the commercial market.

1.2 Standards, Quality Assurance and Asymmetric Information

Stipulating and enforcing standards for product quality, safety, and labeling falls under the purview of governments. Standards are particularly important for credence goods, whose attributes cannot be verified by the consumer even after the item has been purchased or consumed. For example, ingredient ratios and fortification claims are credence attributes – a consumer cannot know even after feeding a child whether the product was truly fortified or contained the stated amounts of each nutrient. As a result, caregivers may rely on brand names or higher prices to determine food quality and safety, bypassing unbranded or lesser-known products which tend to be less expensive. This allows larger companies with more market control to provide these products in smaller quantities, as is the case with CPC in Malawi (Masters, Kuwornu, and Sarpong 2011).

A few international and national standards have been set to protect the integrity and quality of CPCs. These standards include stipulations that products should be free of contaminants and that labels should provide consumers with necessary and accurate information about product attributes and content. The Codex Alimentarius Commission (Codex), an international body formed jointly by World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations, formulates food safety standards, including nutrient requirements for infant foods and maximum allowable levels for certain contaminants. In Malawi, the Malawi Bureau of Standards (MBS) is responsible for the development, promotion, and enforcement of standards. At the time of writing, fortified, premixed cereal-based blends for infants and young children are governed by the 1988 Malawi Standard 90 (MS90:1988) for high protein baby foods. MBS has drafted an updated standard (MS90:2017) for high-protein cereal-based foods for infants and young children, which awaits finalization and gazetting. However, no single international or national standard now exists that encompasses CPC nutrient composition, potential contaminants, and labeling or marketing requirements.

The actual nutrient composition of available CPCs has recently been measured in a few studies, including a study of 108 premixed complementary foods in 22 low and middle-income countries that found significant differences between claimed and actual densities of protein and fat in the foods, of which only slightly more than 20 percent met iron and zinc standards (Masters, Nene, and Bell 2017). Studies across countries in Africa south of the Sahara have found inadequate nutritional content in CPCs relative to benchmarks (Faber 2005; Gibson, Ferguson, and Lehrfeld 1998). In a study of both imported and locally-produced premixed cereal-based blends in Benin, Burkina Faso, Ghana, and Senegal, only 22 percent of products were nutritionally satisfactory, defined as meeting more than seven of ten requirements for protein, fat, and various vitamins and minerals (Dimaria et al. 2018). A study of both homemade cereals and CPCs in Tanzania found that while most commercial products provided reasonable percentages of the recommended daily allowances for nutrients and energy, there were issues with nutrient composition and energy balance. In particular, products were low in fat, iron, calcium, zinc, and phosphorus, but high in crude fiber, carbohydrates and magnesium (Mosha, Laswai, and Tetens 2000). Most recently, a study of CPCs in Rwanda found low and variable nutrient composition as well as high aflatoxin contamination (Grosshagauer et al. 2019).

Improving the composition of CPCs, and improving the accuracy of their labels and marketing practices, can be seen as an extension of standards governing breastmilk substitutes and infant formulas (Michaud-Létourneau, Gayard, and Pelletier 2019). Unlike formula milks, CPCs are solid foods that complement continued breastfeeding, and primarily displace other grain-based porridges (Cliffer, Masters, and Rogers 2019). The regulation of formula milks is even more challenging than the regulation of infant cereals, however, and a 2008 report on food labeling oversight in the United States found that 40 percent of infant formulas tested were in violation of U.S. regulations (U.S. Government Accountability Office 2008).

Concerns about misleading food labels, and opportunities to improve the regulation of food packaging and marketing, are particularly important for CPCs but also apply to other food categories. While there is limited literature on labeling in Malawi, a 2013 study of nutrition labels found that more than half of the processed foods that made nutrition claims on their packaging or in their advertising did not have corresponding nutritional information (Kasapila and Shaarani 2013). A 2015 study of breads in Blantyre found that none of the brands sampled complied with nutrition labeling guidelines (Gama and Ching’anda 2015).

Maximum levels for contaminants such as mycotoxins are included in both international and Malawi’s national standards for a variety of foods. Mycotoxins are secondary metabolites produced by fungi which commonly grow on maize, wheat, groundnuts, and other crops due to poor pre- and post-harvest conditions and management. Mycotoxins are present in a wide variety of environments, but are particularly common in warm, humid places like Malawi. Aflatoxin is among the best-known mycotoxins, although other like fumonisin and deoxynivalenol (DON) have received increased attention in recent years.

1.3 Mycotoxin Contamination and Child Health

Both acute and chronic mycotoxin exposure carry significant health consequences. The International Agency for Research on Cancer (IARC) has established aflatoxin as a known carcinogen (IARC 2012). Aflatoxin has also been linked to immunosuppression and increased disease susceptibility (Gong, Watson, and Routledge 2016). In sufficiently large doses, aflatoxins can cause acute poisoning known as aflatoxicosis (WHO 2018). While less is known about the health effects of fumonisin in humans, IARC has classified it as a Group 2B compound signifying that it is "probably carcinogenic to humans." Fumonisin is also potentially neurotoxic and has been linked to neural tube defects (Domijan 2012).

Given their intake per unit of body weight, infants and young children are at a higher risk of experiencing the adverse health effects associated with mycotoxin exposure. Mycotoxin exposure is associated with poor child growth and stunting, although recent studies have highlighted the complicated nature of the relationship and the need for more research (Gong, Watson, and Routledge 2016; Egal et al. 2005; Smith et al. 2015; Lombard 2014; Mupunga, Mngqawa, and Katerere 2017; Kiarie et al. 2016; Leroy et al. 2018; Hoffmann, Jones, and Leroy 2018). Exposure in utero, via breastmilk, or in complementary and family foods can limit child development through various pathways, for example through environmental enteropathy or impaired immune system function (Leroy and Frongillo 2019; Smith, Stoltzfus, and Prendergast 2012).

In Malawi, mycotoxins are common in maize and groundnuts (Matumba et al. 2009, 2014; Monyo et al. 2012). Matumba (2009) detected aflatoxin in 45 percent of samples of stored maize in villages in Lilongwe district, while Mwalwayo and Thole (2016) found that 20 percent of maize samples collected from household stores exceeded the maximum limit for aflatoxin set for Malawi of 3 parts per billion (ppb). While only 10 percent of the samples had levels of fumonisin that exceeded the maximum limit set by Codex for unprocessed maize (4 ppb), the coexistence of aflatoxins and fumonisin in samples and potentially higher health risks when the mycotoxins coexist suggest that this is an area for further study (Kumar et al. 2017). Monyo et al. (2012) reported that over 40 percent of stored groundnuts and between 17 and 44 percent of fresh groundnuts in various districts had aflatoxin levels above the 4 ppb standard set by the European Union (EU). Forty-two percent of maize samples collected in 2011, 2012 and 2016 from 20 districts in Malawi were above the national regulatory limit of 3 ppb, while 22 percent exceeded the 20 ppb limit used in the United States (PACA 2018). There is also evidence of higher aflatoxin concentrations in the southern part of the country (PACA 2018; Mwalwayo and Thole 2016).

Contamination of these food crops is disconcerting as home-produced and commercially-available infant cereals are primarily comprised of maize and groundnut or other grain legume flours. A study of both locally-processed and imported foods, including instant baby cereals, de-hulled maize flour, and peanut-based therapeutic foods in Lilongwe found that all locally-processed maize-based baby foods and peanut-based therapeutic foods tested had aflatoxin levels above EU limits for infants (Matumba et al. 2014). Research from other countries found that home-produced porridges may be as or more contaminated with mycotoxins than commercially-sold products (Hotz and Gibson 2001). In Nigeria, a study of 110 infants found that 93 percent of made-at-home complementary foods contained mycotoxins compared to 42 percent of processed foods (Ojuri et al. 2018).

While standards for aflatoxin contamination were included in MS90:1988 for high-protein infant cereals, new more stringent standards have been proposed in the draft Malawi Standard 90 (DMS90:2017) for high-protein cereal-based foods for infants and young children. The new draft standard proposes limits for deoxynivalenol (DON) but does not propose standards for fumonisin.[4]

[4] The Codex standard for maize flour, which serves as the basis for many cereal-based blends in Malawi, limits total fumonisin to 2000 micrograms per kilogram (µg/kg). However, a limit of 15 µg/kg (0.015 ppm) can be set following the recommendation of FAO and WHO's Joint Expert Committee on Food Additives (JECFA), an international expert scientific committee set health-based guidance values of 2 µg/kg body weight/day (JECFA 2016), assuming a median weight of 7.5 kg for a six-month-old child (Maleta 2003).

Given concerns about appropriate complementary feeding for reducing malnutrition among infants, mycotoxin contamination, and poor nutritional quality of complementary foods, this study examines the quality of commercially-sold complementary foods, namely fortified and premixed cereal-based blends sold in central and southern Malawi. Our work adds to the literature on the quality of commercial complementary foods by adding a larger number and wider range of observations alongside qualitative evidence from stakeholder interviews. This research aims to broaden discussions around food safety and quality that tend to receive less attention in the traditional food and nutrition security rhetoric in Malawi, as well as propose solutions that could improve complementary foods in other low- and middle-income countries which face similar problems.

2 DATA AND METHODS

2.1 Study Area and Sample Collection Protocol

The dispersion and variability of commercially-sold premixed cereals in Malawi is not well documented. This study relied on a stratified sample of 94 CPCs collected in marketplaces in the central region where the National Statistical Office collects price data, as well as in smaller retail outlets and supermarkets in the central and southern regions where such cereals were commonly available for sale (Figure 1). This sample spans markets and neighborhood shops frequented by low and middle-income shoppers and supermarkets frequented by higher-income shoppers. Samples were collected between June and August 2018.

Figure 1. Map of sample collection sites

***Source**: Authors' representation.*
***Note**: The boundaries and designations used on maps do not imply official endorsement or acceptance by IFPRI.*

The samples collected were CPCs marketed for the feeding of infants and young children or sold adjacent to such products and marketed to the whole family. The latter were included because they may be used to feed infants if caregivers are unaware of appropriate IYCF practices or for their convenience and cost-effectiveness among other reasons. We considered such CPC to be important to better understand the effects of targeting, marketing, and labeling regulations.

Our sample included eight widely available brands: four locally-produced and four imported, as well as various CPCs produced on a smaller scale in Malawi which were less widely available. To better understand variability across the CPC samples of both nutritional content and mycotoxin contamination, samples with different manufacturing dates were collected to the extent possible.

Table 1. Descriptive statistics of premixed cereal samples

	All	Infant	Local	Imported
Number of samples	94	78	37	57
%	100	83	39	61
Characteristics		**% of samples**		
Added vitamins/minerals	96	100	89	100
Maize is primary cereal	71	65	100	53
Wheat is primary cereal	32	33	11	46
Includes soy flour	45	36	100	9
Includes milk powder	62	69	58	65
Includes added sugar	85	94	61	100
		Mean ± SD		
Price per 100g (MWK)	479 ± 379	554 ± 373	114 ± 40	716 ± 303

***Note:** *The "infant" column represents a subset of fortified, premixed cereal-based blends which were targeted specifically at infants, excluding products which were marketed to the whole family. Calculations exclude samples where information on ingredients or fortification status was unavailable. SD = standard deviation.*

Of the 94 samples collected, the majority (83 percent) were specifically marketed as infant cereals (Table 1). More than two-thirds of the cereals collected were maize-flour based, and 45 percent included soy flour. Foreign brands were less likely to rely on the traditional corn-soy blend formula than Malawian products. All foreign brands had added sugar, compared to 61 percent of Malawian brands. Close to two-thirds had added milk powder. Imported cereals were notably more expensive than their local counterparts, with an average price of 716 Malawi Kwacha (MWK) per 100 grams of cereal compared to only 114 MWK for locally-produced cereals.[5] Locally-produced cereals varied less in price than imported products.

2.2 Testing Protocol

All samples were decanted from their original packaging into 250-gram portions and double-bagged to avoid cross-contamination. For samples sold in packages less than 250 grams, multiple boxes of the same brand, flavor and batch (i.e. manufacturing date) were combined into a single, mixed sample. Each sample was given an individual code corresponding to sample codes assigned in the Kobo Toolbox form and on labels attached to the original packages at the time of collection. Original packaging was kept for data verification purposes.

Samples were then transported from the International Food Policy Research Institute office in Lilongwe, Malawi to Boston, Massachusetts, USA in checked luggage, accompanied by an investigator, then shipped via the United States Postal Service to Midwest Laboratories in Omaha, Nebraska. As stipulated by the United States' Food Safety Modernization Act, all samples were registered before entry in the US Food and Drug Administration's Prior Notice System Interface (PNSI) for Importing Food Products into the United States. On receipt of the samples, identified only by code numbers, Midwest Laboratories conducted proximate analyses for moisture and ash, protein, fat, carbohydrates by subtraction, and total kilocalories per gram, as well as testing for iron, zinc, aflatoxin and fumonisin, following protocols set by the Association of Official Analytical Chemists.[6] Iron and zinc were chosen as sentinel micronutrients because they are among the minerals most likely to be limiting in breastfed infants' diets (Dewey 2013; Roess et al. 2018). According to the most recent Malawi Micronutrient Survey, an estimated 22 percent of children ages 6–59 months were iron deficient in 2016, 9 percent had iron-deficiency anemia and 60 percent were zinc deficient (NSO et al. 2017). Vitamin A and other micronutrients, as well as microbiological or heavy metal contaminants are also of interest but were not tested due to cost constraints.

2.3 Policy Narratives and Key Informant Interviews

To inform potential policy responses to information about CPC quality, we conducted semi-structured interviews with a variety of stakeholders involved in the market for CPCs in Malawi. Initial key informants were identified by contacting the organizations involved in the Malawi Bureau of Standards (MBS) Technical Committee 10 on Processed Foods, which discussed the draft standard DMS 90:2017; *High-protein cereal-based foods for infants and young children - Specification (Second edition)*, followed by snowball sampling. The resulting narratives were meant to describe expectations, aspirations and concerns related to the new standard and to understand factors which facilitate or impede quality assurance in CPCs.

---

[5] 1 USD was worth approximately 789 Malawi Kwacha as of June 30, 2019 (Bureau of the Fiscal Service 2019).

[6] Tests were conducted as follows: Moisture (vacuum oven), AOAC variable; Protein MWL FO 014; Fat (acid hydrolysis; Ash MWL FO 022; Calories - 21 CFR PART 101.9 (CALC). The sample analysis for aflatoxin and fumonisin followed MWL LCMS 020 which is based on AOAC 2008.02 (modified). Samples are ground to a homogenous consistency and placed in an extraction solution. The extract is allowed to equilibrate and then an aliquot passed through an immunoaffinity column which contains antibodies that are specific for the mycotoxins. The mycotoxins are released from the affinity column and then analyzed by either LC/MS and/or LC/MS/MS which allows identification of the mycotoxins using mass spectrometry and retention time.

We conducted a total of 20 key informant interviews (Table 2), with individuals representing a wide variety of government agencies, non-governmental organizations, CPC producers, and authorities on nutrition and food safety in Malawi. All interviews were conducted in person apart from one telephone interview and one emailed questionnaire. The interview protocol aimed to elicit respondent's views based on their own experience, interests and area of expertise, based on open-ended prompts.

Table 2. Key informant interviews by sector

Stakeholder	# of interviews
Government	2
Malawi Bureau of Standards	3
Academia	3
Producers & private sector	8
Non-profit/NGO	4
Total	**20**

2.4 Ethical Approvals

The methods employed in this study were approved by the Tufts University Institutional Review Board for Social, Behavioral, and Educational Research (IRB approval number: 1833040) and the Malawi National Commission on Research in the Social Sciences and Humanities (IRB Approval Number: p.05/18/268).

2.5 Data Cleaning and Analysis

Data on labeled product attributes, prices, and location of purchase were collected electronically using KoBo Toolbox on Android tablets. Individual entries were randomly audited for accuracy using original packaging. All data were stored and cleaned in Microsoft Excel and analyzed in STATA version 15.1 (StataCorp, College Station, TX).

Any samples in which aflatoxin or fumonisin levels were below the threshold level of detection were replaced with zero values for this analysis.[7] As extreme values were of interest in this study, outliers were not removed from the sample. Rather, multiple measures of central tendency are reported as needed.

Nutrient composition of samples was compared to national standards, namely the Malawi Bureau of Standards' 1988 Malawi Standard 90 (MS90:1988) for high protein baby foods and the updated draft standard (MS90:2017) for high-protein cereal-based foods for infants and young children. Following Masters, Nene and Bell (2017), samples were also compared to three international standards. The first is a standard set by the Codex Alimentarius Commission (FAO and WHO 2017). We also use standards set for the formulation of Super Cereal Plus (SCP), a corn-soy blend with milk powder, sugar, vegetable oil, and vitamin and mineral premix (Webb et al. 2011; WFP, n.d.). SCP is specifically designed for complementary feeding and widely used by the United Nations and other donor organizations. Lastly, we use standards published by Lutter and Dewey (2003) as part of a consultative process convened by the Pan American Health Organization in 2001. Tested values were compared against each of these benchmarks.

For analysis of the difference between labeled and tested nutrient composition, non-parametric Wilcoxon matched-pairs signed-ranks tests were used to test whether the distributions of labeled and tested values were equal for all samples with corresponding labeled data available.

[7] Detectable levels for aflatoxin were 1.00 parts per billion, and detectable levels for fumonisin were 0.1 parts per million. Non-detectable levels are not necessarily equivalent to zero.

3 RESULTS AND DISCUSSION

3.1 Tested Proximate Composition and Nutrient Levels

All CPC samples collected were compliant with Malawi's ash standards, and nearly all were compliant with minimum standards set for iron (97 percent) and maximum standards set for moisture (98 percent) (Table 3). Moisture adds to the weight of the product without adding nutritional content and can contribute to the growth of contaminants in a food product if not managed appropriately. Ash is a measure of total mineral content in foods.

Table 3. Proximate and nutrient composition of samples & compliance with Malawi standards

		All	All	All	Infant	Fortified	Local	Imported
Number of samples		94	94	94	78	90	37	57
Nutrient	**Required level**	**Med (IQR)**	**Mean ± SD**	**% of samples that met standard**				
Protein	14 g/100 g (min)	14.2 (1.9)	13.5 ± 2.8	56	56	58	78	42
Fat	8 g/100 g (max)	8.8 (5.7)	7.4 ± 2.9	39	38	38	16	54
Moisture	11% (max)	5.6 (2.8)	5.4 ± 2.1	98	97	98	100	96
Ash	5% (max)*	2.4 (0.8)	2.4 ± 0.7	100	100	100	100	100
Iron	4 mg/100 g*	16.0 (9.4)	16.5 ± 9.7	97	100	100	92	100
Zinc	5 mg/100 g*	4.1 (2.6)	4.6 ± 2.0	35	35	37	30	39

Note: *The Malawi standards presented here are those included in MS90:1988 for high-protein infant cereals, and those which are starred (*) have been proposed in the draft Malawi Standard 90 (DMS90:2017) for high-protein cereal-based foods for infants and young children. SD = standard deviation; IQR = interquartile range; Med = median/50th percentile.*

While almost all cereals met Malawi iron standards, nearly two-thirds of samples (65 percent) did not meet zinc standards. This was an issue for both imported and locally produced brands, irrespective of label claims about micronutrient fortification. Zinc content ranged from 2.0 to 10.8 grams per 100 grams of cereal. Iron content was high relative to the benchmark set in the Malawi standard, as well as highly variable.

Macronutrient content was also problematic in a large percentage of cereals. Only 39 percent of cereals met the Malawi standard for fat, which specifies a maximum of 8 percent fat by mass of the product as sold. Fat content ranged from 1.7 to 11.8 grams per 100 grams of cereal, with the majority of samples surpassing the standard. However, international standards for fat content are more commonly set as minimum rather than maximum standards to ensure adequate energy density of the food (Table 4). Forty-four percent of cereals did not meet Malawi protein standards, stipulating a minimum of 14 g of protein/100 g. On average, locally-produced cereals had higher protein and fat content than imported brands.

Two of the brands collected have a subset of products that clearly specify that the product should be prepared with any type of added milk. This would increase both the protein and fat content of the cereals. Even when these "add milk" cereals are removed from the sample, 41 percent of the cereals for which only water might be added had inadequate protein content, and 73 percent had inadequate fat content.

Table 4. Premixed cereals' compliance with international infant food standards

	Codex		Super Cereal Plus		Lutter & Dewey	
Nutrient (per 100 g)	**Standard**	**% met**	**Standard**	**% met**	**Standard**	**% met**
Energy (kcal)	400.0	63	410.0	52	440.0	0
Protein (g)	6.0	97	16.0	15	6.0	97
Fat (g)	9.0	45	9.0	45	12.7	0
Iron (mg)	11.0	71	12.5	62	14.0	57
Zinc (mg)*	4.1	50	7.6	9	8.3	4

Note*: Data shown are percentages of the 94 samples that met or exceeded each benchmark. Benchmarks are reproduced from Masters, Nene and Bell 2017, from Webb et al. 2011 and Lutter and Dewey 2003.*

International and published standards for energy, which are not stipulated by MBS, range between 400 and 440 kilocalories per 100 grams of cereal (Table 4). None of the cereals met Lutter and Dewey's higher energy standards, while 63 percent of samples met the lower Codex standards (Table 4). As was the case with protein and fat content, Malawian cereals had significantly higher average calorie content (411 kcal/100 g) than imported brands (403 kcal/100 g). Energy-dense foods are important to support the rapid growth of young children whose stomachs can only handle small portions of food.

While nearly all samples met the lower protein standard stipulated by both Codex and Lutter and Dewey (97percent), the higher protein standard for SCP was achieved by only 15 percent of the cereals. No cereals met fat standards set by Lutter and Dewey (12.7 g), and less than half of the samples met the less stringent standard of 9 grams. Only half of samples met the lowest benchmark for zinc, and a mere 4 percent complied with Lutter and Dewey's proposed zinc standard of 8.3 mg per 100 grams.[8]

3.2 Mycotoxin Contamination Levels

Positively, both aflatoxin and fumonisin levels were below detection thresholds in 57 percent of samples. Furthermore, two-thirds of CPCs had total aflatoxin levels below the 0.1 parts per billion (ppb) ceiling set by the European Union and other international bodies for infant foods. This is the proposed Malawi standard for aflatoxin in DMS90:2017.

Only 19 percent of cereals produced in Malawi had aflatoxin levels that met the international standard, and 44 percent of Malawian CPCs did not meet the current Malawian standard for total aflatoxin which is a maximum of 12.5 ppb and has been in place since 1988 (Table 5). While 66 percent of all samples had fumonisin concentrations below JECFA guidance levels, only 16 percent of cereals produced in Malawi met these health-based guidelines.

Table 5. Mycotoxin levels and compliance with existing and proposed standards

			All	All	All	Infant	Fortified	Local	Imported
Number of samples			94	94	94	78	90	37	57
Mycotoxin	**Standard**	**Upper limit [c]**	**Med (IQR)**	**Mean ± SD**	**% of samples that met standard**				
Aflatoxin	MS90:1988	12.5	0 (5.0)	5.7 ± 12.5	83	81	82	56	100
Aflatoxin	DMS90:2017	0.1	0 (5.0)	5.7 ± 12.5	66	69	66	19	96
Fumonisin [a]	Codex	2.0	0 (0.2)	0.4 ± 0.7	95	96	94	86	100
Fumonisin [b]	JECFA	0.015	0 (0.2)	0.4 ± 0.7	66	73	66	16	97

Note: *The current aflatoxin standard is included in MS90:1988 for high-protein infant cereals, while the proposed aflatoxin standard is included in the draft Malawi Standard 90 (DMS90:2017) for high-protein cereal-based foods for infants and young children. [a] Fumonisin levels are not included in either Malawi standard for infant foods. Codex standards are set at 2000 micrograms per kilogram (µg/kg) for maize flour and as such are presented as a reference point. [b] Fumonisin level is set using health-based guidance values of 2 µg/kg body weight/day (JECFA 2016), assuming a median weight of 7.5 kg for a six-month-old child (Maleta 2003). [c] Limits for aflatoxin are in parts per billion (ppb) and limits in fumonisin in parts per million (ppm). Non-detectable levels for aflatoxin and fumonisin were replaced with zeros for this analysis. SD = standard deviation; IQR = interquartile range; Med = median/50th percentile.*

Cereals produced in Malawi had significantly higher aflatoxin and fumonisin levels than imported brands (Table 6). Malawian CPCs also had highly variable aflatoxin concentrations, ranging from undetectable levels to 89.2 ppb. These high levels were driven by aflatoxin B1, a potent carcinogen and among the most dangerous aflatoxin compounds known. Fifteen percent of cereals had concentrations two orders of magnitude higher than the EU standard for baby foods (0.1 ppb AFLB1).

[8] Lutter and Dewey (2003) consider both nutrient bioavailability and the ration size; "The daily ration of a fortified complementary food should contain 4–5 mg of zinc as described by Rosado (27). This exceeds the RDA of 3 mg and is justified because of the lower bioavailability of zinc in cereal-based diets typical in developing countries" (p. 3016S).

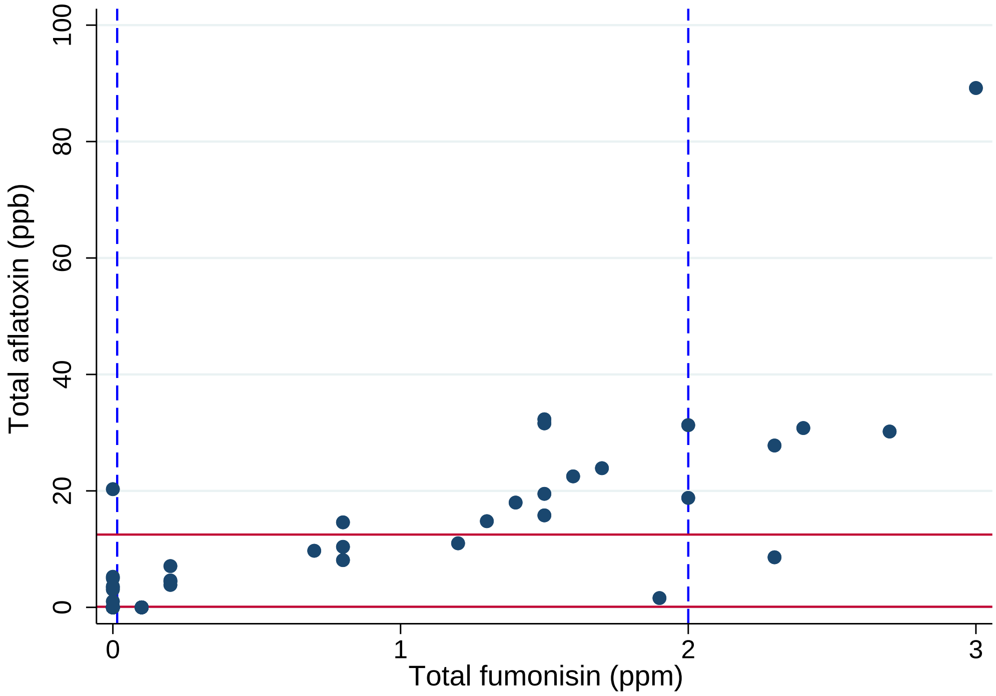
Table 6. Aflatoxin and fumonisin contamination in imported and locally-produced cereals

	Imported		Local		Significance of difference
	Mean	SD	Mean	SD	
Aflatoxin (ppb)					
B1	0.05	0.30	8.40	8.94	***
B2	0.00	0.00	0.67	0.97	***
G1	0.02	0.18	4.82	7.15	***
G2	0.00	0.00	0.37	0.96	**
Summation	0.08	0.47	14.26	16.63	***
Fumonisin (ppm)					
B1	0.00	0.02	0.77	0.69	***
B2	0.00	0.00	0.20	0.21	***
B3	0.00	0.00	0.02	0.04	***
Summation	0.00	0.02	0.98	0.92	***
Number of samples	57		37		

Note: *Significance is based on p-values from ttest with unequal variances where *** p<0.01, ** p<0.05, * p<0.1. SD = standard deviation.*

Furthermore, using the two more stringent standards for total aflatoxin and fumonisin (0.01 ppb and 0.015 ppm), 25 samples showed both total aflatoxin and total fumonisin above their respective limits in a single cereal (Figure 2). This is particularly concerning considering suspected negative effects of co-exposure.

Figure 2. Aflatoxin and fumonisin levels relative to current standards and proposed limits



Note: *Figure includes all samples (N=94); samples with undetected levels of both aflatoxin and fumonisin are clustered at the origin (N=57).Horizontal red lines indicate current and proposed limits for total aflatoxin (12.5 and 0.1 parts per billion). Vertical blue dashed lines indicate limits for total fumonisin (0.015 ppm based on intakes for young children and Codex standards for maize flour).*

3.3 Labeled and Tested Nutrient Content and Tolerable Upper Limits

An additional point of interest was whether nutrition labels on the cereal package accurately reflected the nutrient content of the cereal. This analysis focused on a subset of the nutrition facts reported on the labels, namely energy density (calories), macronutrient content (carbohydrates, protein, and fats), and iron and zinc. As some samples were collected from producers at the request of the study team, rather than purchased directly from retail outlets, they had not been labeled. While 89 of 94 samples had some nutrition labeling on the package, not all products provided information on all nutrients. For example, only 61 samples labeled carbohydrate content.

All tested nutrients were significantly different (*p*<0.05) from their labeled values except for protein and zinc (Table 7). This result was expected given global difficulties with accurate labeling practices. For all CPC components, labeled content was lower than the tested content on average.

Table 7. Differences between labeled and tested nutrient content

Nutrient (per 100 g DM)	Labeled mean ± SE	Tested mean ±SE	Difference mean ± SE	Diff/Label (%)	Wil. p-value	N
Calories (kcal)	394.3 ± 3.9	406.0 ± 1.9	-11.7 ± 3.2	3.0%	0.000	89
Carbohydrates (g)	70.3 ± 0.6	73.1 ± 0.7	-2.8 ± 0.7	4.0%	0.002	61
Protein (g)	13.1 ± 0.3	13.4 ± 0.3	-0.3 ± 0.2	2.3%	0.082	89
Fats (g)	6.2 ± 0.3	7.3 ± 0.3	-1.1 ± 0.1	17.7%	0.000	87
Iron (mg)	12.4 ± 1.0	17.1 ± 1.1	-4.8 ± 0.3	38.7%	0.000	81
Zinc (mg)	4.3 ± 0.1	4.5 ± 0.2	-0.2 ± 0.2	4.7%	0.483	75

Note: *Only observations with both labeled and tested values are included for each nutrient. DM = dry matter; SE = standard error of the mean. A standard serving size for these cereals is 50 grams, although this varies by product, such that 100 grams is equal to two servings of infant cereal for most of the cereals collected, and thus represents the quantity a child would likely eat if fed the recommended portion twice a day. Differences (diff.) were calculated as labeled values minus tested values, such that all negative differences indicate that the label understated the quantity of the nutrient in the product. P-value is for the non-parametric Wilcoxon matched pairs test, testing that the distributions of labeled and tested values are equal.*

For many nutrients the difference between actual and labeled values is of limited practical significance for diet quality, averaging less than five percent of the labeled value for calories, carbohydrates, protein, and zinc. However, for fat and iron, the average differences between actual and labeled values were 18 and 39 percent of the total labeled content, respectively (Table 7).

Table 8. Labeled and tested nutrient content relative to infants' desired nutrient intake

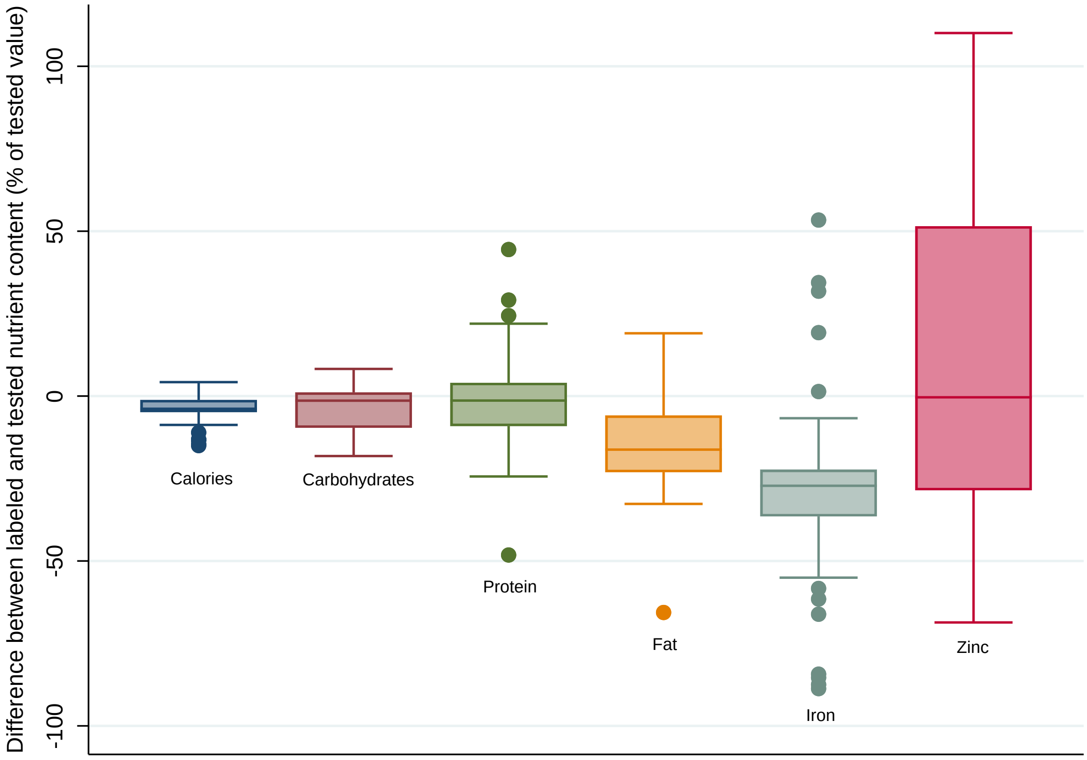
	Difference (label-tested)		Desired intake from comp. food [a]		Median diff as % of desired intake			
Nutrient (per 100 g DM)	Median	Largest	6 mos. of age	24 mos. of age	6 mos. of age	24 mos. of age	Tested min.	Tested max.
Calories (kcal)	-15.0	235.8	167.3	633.4	9.0	2.4	346.0	435.0
Carbohydrates (g)	-1.1	-14.0	NA	NA	NA	NA	61.9	82.8
Protein (g)	-0.2	-4.0	3.3	6.0	6.1	3.3	5.3	18.5
Fats (g)	-1.0	-3.4	0.0	17.5	NA	5.7	1.7	11.8
Iron (mg)	-4.5	-12.7	9.1	5.6	49.5	80.4	3.2	49.3
Zinc (mg)	0.0	-4.8	3.3	3.4	0.9	0.9	2.0	10.8

Source: *[a] Desired intakes from a complementary food are taken from Table 3 of Masters, Nene and Bell (2017).*
Note: *DM = dry matter. NA = not available/applicable. Differences (diff.) were calculated as labeled values minus tested values, such that all negative differences indicate that the label understated the quantity of the nutrient in the product. Desired intake is the amount an infant of 6 or 24 months would need from a complementary food based on estimated breastmilk intake.*

These differences between labeled and tested values often represent a small percentage of estimated intake requirements for infants (Table 8). For example, the median difference of 15 kilocalories per 100 grams of infant cereal represents only 9 percent of the desired caloric intake that a 6-month-old child should receive from a complementary food (Masters, Nene, and Bell 2017). However, half of the samples understated iron content by 4.5 mg or more per 100 grams of premixed cereal, or 49.5 percent of a 6-month-old child's desired iron intake from complementary foods. There were also instances of extreme errors in labeling. The largest relative differences recorded were for iron (-12.7 mg/100 g), calories (235.8 kcal/100 g), and zinc (-4.8 mg/100 g), each representing more than an infant's entire recommended daily intake.

The nutrients that were most inaccurately labeled relative to their tested values were iron and fat (Figure 3). While on average protein and zinc were correctly labeled, there were also large high and low labeling errors for these nutrients. Both on average and in terms of the largest labeling inaccuracies, mislabeling resulted in the understatement of the product's nutrient content. This suggests problems with formulation or testing rather than malintent of the manufacturer to overstate the nutritional value of their product.

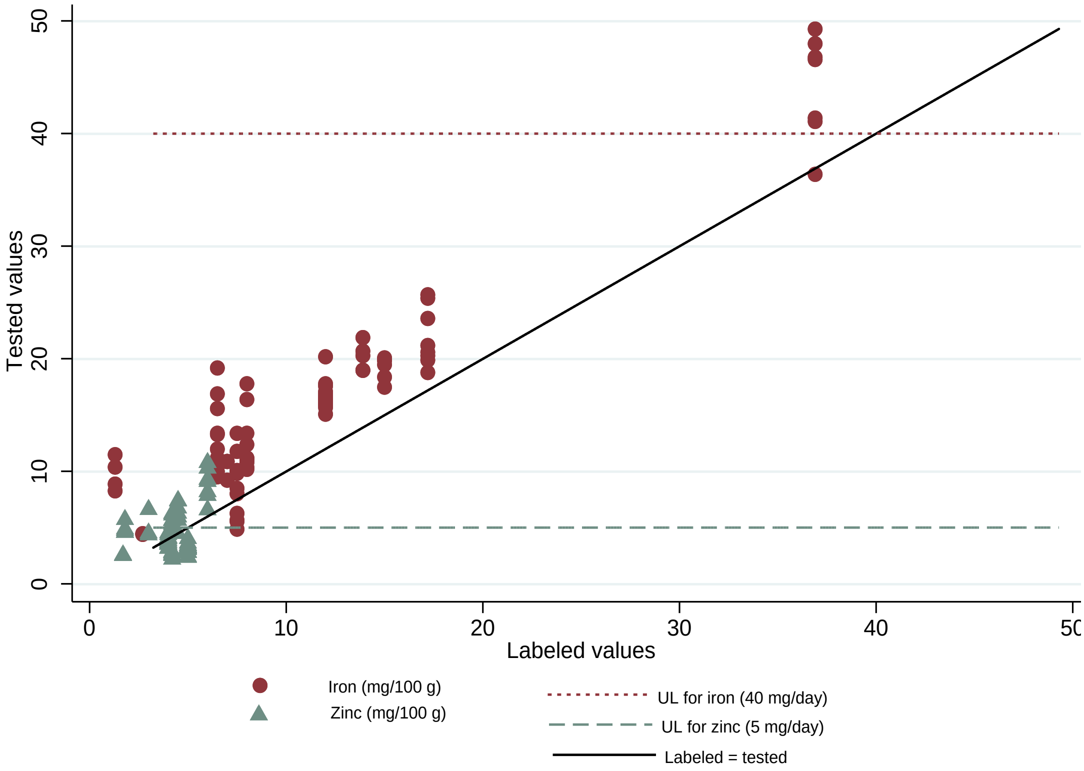
Figure 3. Differences in labeled and tested nutrient content (% of tested value)



Note: *All values are calculated as the difference between labeled – tested values, presented as a percentage of the tested value. A value of zero indicates that the labeled value is equal to the tested value. Filled circles indicate outliers (defined as 1.5 times the interquartile range), which were kept in the analysis to demonstrate the most severe cases of inaccurate labeling, with the exception of one outlier in labeled kilocalories that was removed for this figure only, to improve readability (diff=236 kilocalories). Negative numbers indicate that the label understated the amount of the nutrient present in the actual cereal product.*

Labeling errors of this magnitude can impact children's health, particularly if minerals like iron and zinc exceed Tolerable Upper Limits (UL). UL are estimates of the highest level of continued daily intake that poses no risk to the majority of the population (USDA 2009; Zlotkin 2006). These upper limits have been estimated for both zinc (5 mg/day for infants age 7–12 months) and iron (40 mg/day) and are shown in Figure 4 for a child consuming a reference amount of 100 g of cereal per day. Too much zinc can cause nausea, vomiting, and diarrhea, symptoms, which aside from being harmful could also discourage caregivers from feeding the child the problematic food again.

Figure 4. Tolerable upper limits and labeling inaccuracies for iron and zinc



Six samples had levels of iron that exceeded the UL, and 33 had levels of zinc exceeding the UL for children 7-12 months of age (Figure 4). Tested values for iron were also larger than labeled values in 80 percent of cases, and zinc content was higher than the labeled value 40 percent of the time.

4 KEY INFORMANT INTERVIEWS

Key informant interviews highlighted various challenges to improved provision and regulation of CPCs in Malawi. [9] Challenges can be classified by (1) recognized weakness of existing quality assurance processes; (2) the cost of and resources required for improved quality control, particularly for small-scale and aspiring producers; and (3) differences in cost between control of nutrient composition via ingredient ratios and the more comprehensive challenge of preventing mycotoxin contamination throughout the supply chain.

4.1 Food Safety and Quality Assurance in Malawi

Current weaknesses in the existing regulatory framework for food safety and quality in Malawi were highlighted by several stakeholders, who emphasized the need for more efforts in three distinct areas:

1. Development and dissemination of appropriate standards;
2. Market surveillance, quality certification, and standards enforcement; and
3. Government capacity to oversee both the formulation and enforcement of standards.

[9] Information from key informant interviews was verified by background research to the extent possible, but notes should be read as the perspectives and understanding of key informants. All informants were asked to review notes taken during their interviews and make corrections, although not all informants chose to do so. While some informants stated that they were comfortable with their names and affiliations being shared in written reports, to adequately protect study participants we chose to keep all informants' identities anonymous. Multiple interviews touched on counterpart cereals to CPCs that are widely used in both development and emergency nutrition assistance programs in Malawi. In some cases, these cereals are manufactured by the same local producers in the same facilities where the CPCs in the sample were produced.

Key informants noted that MBS struggles to develop clear, appropriate standards for the diversity of food and non-food products manufactured and sold in Malawi. The impetus for drafting the new Malawi Standard 90 was that the original standard was inappropriate for many infant cereals being manufactured. Coliform and contaminant levels had been set for ready-to-eat foods rather than cereal-based products, which are cooked or mixed with boiling water before being eaten. This issue was addressed after being brought to the attention of MBS by the large-scale producers and users of corn-soy blend (CSB) for development programming, who struggled to pass MBS quality checks. The original standard was developed in 1988 and was meant to be revisited every five years.

Another informant noted that some CPCs are not targeted at infants and should be categorized separately. A local company looking to diversify its products also felt that the standard was most appropriate for corn-soy blends manufactured using extrusion cooking and found it difficult to meet new standards using different primary ingredients or processing techniques. These critiques suggest the need for additional standards.

With regards to labeling, informants were unclear about whether national standards were mandatory or set as voluntary guidelines.[10] This confusion was pervasive, even within MBS. For example, several informants mentioned that there was a lack of clarity on whether producers making broad fortification claims are required to include vitamin and mineral content on nutrition labels, which was missing for some local brands. Interviews also revealed suspicions that some food processors make product labels for the MBS certification process by borrowing nutrient content information from similar products and some informants stated that the actual composition of local products is rarely analyzed.

Interviewees also expressed concern about the process for revising standards and bringing them into force is inefficient. The drafting process for MS90 began in May 2017 but has been stalled for two years at the time of writing this report. The revised MS90 can improve infant food quality, with new limits for aflatoxin and the introduction of deoxynivalenol, iron, zinc, folic acid, and vitamin A standards. Yet delays and poor dissemination of the standard limit its potential impact. Many key informants were unaware of the new standard, even in cases where a representative of their organization had been involved in the drafting process. The high price and inconvenience of obtaining hard copies of standards from the MBS office in Blantyre also impede awareness and potential quality improvements.[11]

Interviewees also noted lax enforcement of standards. Informants mentioned the inadequate financial and human capacity of the Bureau to regulate the large number of food and non-food items it is tasked with overseeing. Lab facilities, personnel, and technical training opportunities are insufficient. Informants suggested that a limited number of tests are conducted for certification purposes only (i.e. use of the MBS pre-certified and certified seals) rather than for continued market surveillance. It is likely that adulterated products remain on store shelves and that certification seals are poorly regulated. Rigorous surveillance would require tests for all standards (i.e. microbiology, mycotoxins, fortification levels) to be conducted on a more frequent basis.

4.2 Quality Control Costs and Capabilities

Local infant cereal producers expressed concerns about the costs of quality control measures, from laboratory testing to the cost of importing fortificants, packaging materials, and milling and processing machinery.

Many smaller cereal producers rely exclusively or nearly so on MBS for quality assurance testing. There are multiple independent labs in Malawi and in the region where complementary food producers can send their samples for testing. However, smaller producers feel that these tests are prohibitively expensive and there is a generalized lack of trust in laboratories. One respondent voiced a preference to have MBS send samples to an off-site, independent lab for testing to avoid potential influence over

---

[10] In Malawi, food product labelling is governed by at least three standards and guidelines, including MBS 19:2001 *Labelling of prepacked foods – General standard,* MBS 625: 2001 *Nutrition claims – Guidelines* and MS 654: *Addition of Essential Nutrients to foods – General guidelines.*

[11] We purchased four standards, totalling 31,500 MWK (July 2018). MS 625, a two-page document, cost 9,000 MWK, or roughly US$11. MS90 and MS19 collectively cost 22,500 MWK (for 1 page and 7 pages of content, respectively).

test results, and to allow producers to challenge or verify results that seem inaccurate. Others reported low trust in these same local laboratories to provide consistent, accurate results. Few Malawian laboratories are accredited or participate in proficiency testing. While some larger producers and institutions send samples to South Africa, one producer cited the country's burdensome customs processes and tendency to open packages at the border as deterrents.

Smaller producers of infant cereals also felt particularly burdened by large upfront investments needed to make competitive products that meet MBS standards. Purveyors of vitamin-mineral premix and packaging materials prefer to sell in bulk to larger producers, and the liquidity need for these purchases may be difficult for smaller manufacturers. Two producers specifically cited the need for small-business incubators or credit to scale up and improve their operations.

These constraints often lead smaller-scale producers to operate outside of formal markets or sell to institutions like hospitals or schools rather than directly to consumers. This limits the options caregivers have for feeding their children, particularly given the price premiums on imported products. While many caregivers rely on made-at-home porridges, these are time consuming to prepare and to cook, requiring fuel sources, which are often unavailable, unreliable or expensive.

4.3 Mycotoxin Awareness and Control

The greatest changes in infants' exposure to mycotoxins will come through lower levels in raw materials used in both commercial and homemade complementary foods. While the details of specific mycotoxin control practices have been extensively documented elsewhere (Hell, Mutegi, and Fandohan 2010; Matumba, Chamango, and Munthali 2012) and are beyond the scope of this paper, key informants focused on a few potential intervention points. Numerous interviewees were concerned about early harvesting and improper drying of maize. Moist grain is prone to fungal growth and mycotoxin contamination. Concerns about theft of maize from fields may drive the impulse to harvest early. It was also noted that many farmers lack improved materials for drying crops.

Other key informants expressed concerns about transportation and storage of maize throughout the value chain. Poor storage and warehousing systems or transporting produce in open trucks leaves crops susceptible to weather and pests. Pest damage and moisture promote fungal growth and mycotoxin contamination. While many producers highlighted farm-level practices as the primary driver of mycotoxin levels in processed foods, this question deserves further attention. Ojuri et al. (2019) found significantly higher levels of fumonisins in industrially-processed as compared to homemade complementary foods. Research on mycotoxin levels along value chains can be undertaken to identify key points of intervention, and to help not only farmers but also producers and traders improve crop quality.

Some interviewees proposed grading of commodities like maize and groundnuts to help control mycotoxins in processed foods. Inconsistent crop quality and inability to discern or demand high-quality raw materials is a significant challenge for producers. Grading systems can help address this, in part by offering price incentives for high-quality products. However, two informants expressed concern about concentrating low quality or contaminated products on the Malawian market while high quality raw materials are exported, which has been documented in groundnuts in Malawi (Matumba et al. 2015). One interviewee spoke about developing markets for graded-out products (i.e. groundnut oil or livestock feed cakes) so households can still sell low-quality crops and the concentration of contaminated food in farming households can be avoided.

Various key informants called for public awareness campaigns regarding mycotoxins, particularly as contamination is expected to worsen with a changing climate. One interviewee highlighted low knowledge and awareness of mycotoxins, while others noted a limited understanding of food safety in general. Others were frustrated by siloed mycotoxin mitigation initiatives that ignored potential synergies across sectors. For example, much of the conversation surrounding mycotoxins in the agricultural sector has focused on grading and crop quality for access to groundnut export markets. Simultaneously, nutrition programs have focused on dietary diversity and grading out contaminated maize or groundnuts when preparing children's porridges. One informant highlighted the need for a food safety policy which connects efforts across government entities and development projects dealing with trade, agriculture, and health.

5 CONCLUSIONS

Testing 94 samples of locally-made and imported commercial premixed cereals being sold in Malawi reveals that their nutritional quality is highly variable and often inadequate for infant and young child feeding, particularly with respect to fat, protein, and zinc content. The producers studied do not provide accurate information about the nutrient content of their products, although this appears to be due to issues with nutrient content of raw materials, formulation or infrequent testing of products rather than any intent to overstate nutritional claims. Mycotoxins are often present at high levels, especially in the locally-made products, confirming results of a previous study spanning a wider range of processed foods in Malawi (Matumba et al. 2014).

Credible quality assurance is imperative for long-term availability and affordability of locally-produced complementary foods, which have the potential to improve child nutrition, support local businesses, and provide an incentive for the production of high-quality nutritious crops (Clark and Hobbs 2018). Quality assurance can be provided by either private or public agencies, allowing multiple brands that meet the standard to use a common logo signaling compliance with their standard. In the absence of such a third-party certifier, each seller must use advertising and high prices to signal quality, and the only buyers that can afford their own testing are large institutional purchasers such as aid programs (Masters, Kuwornu, and Sarpong 2011). For household purchasers of everyday foods, certifying agencies can assure quality through periodic inspections and testing, using their third-party logo to indicate that products meet the specified standard. Effective certifiers allow a variety of products and brands to meet or exceed the standard, while sanctioning products that fall below the standard by removing them from the market or prohibiting their sale in the first place.

Quality assurance for commercial premixed cereals in Malawi could be introduced based on either national or international standards for ingredient ratios and nutrient composition, mycotoxin and other contamination, and product labelling. As revealed by our qualitative interviews, improving quality assurance would require new initiatives to alleviate capacity constraints at MBS regarding laboratory facilities, personnel training, and operating funds, as well as greater coordination among government entities involved with market surveillance and food safety. Research in other low- and middle-income countries reveals very similar issues in the market for premixed infant foods, suggesting opportunities for international coordination as well. Certification and market surveillance would allow increased access to higher-quality, lower-cost complementary foods during the 6-24 month period, thereby facilitating the transition from breastfeeding to family diets in Malawi and elsewhere.

5.1 Policy Recommendations

1. Malawi Bureau of Standards should work with the Government of Malawi to streamline the standard gazetting process. Agreed-upon standards for which no substantive or controversial objections have been raised should be brought into force without administrative delays. The Government should work towards making all national standards freely available to the public in electronic form, acknowledging that this relatively minor source of revenue for MBS must be replaced and the Bureau’s other financial constraints addressed.

2. Relevant Ministries and government entities (MBS, Ministry of Health, Ministry of Agriculture, etc.) should coordinate market surveillance activities for food products. Clear, consistent and fairly established repercussions for failure to meet standards should be outlined and enforced. International agencies and private certifiers could be authorized to implement certification schemes, subject to government oversight.

3. For premixed infant cereals in particular, establishing and enforcing a product standard such as MS90 could improve access to lower cost, higher quality products that help caregivers improve complementary feeding. Standards for nutrient composition should be complemented by labeling standards, specifying use by infants after 6 months alongside continued breastfeeding and the gradual introduction of diverse family foods.

4. Standards for mycotoxins and other contaminants in raw ingredients should be extended, stimulating development of markets for high quality grains. These should be enforced alongside initiatives to address concentration of contaminants on local markets.

5. The effectiveness of product standards for premixed infant cereals could be enhanced by support for small- and medium-scale millers and food packaging companies, giving new competitors improved access to high quality raw materials, bulk packaging and fortification products, processing machinery and infrastructure, or training and capacity strengthening activities.

6. The effectiveness of new standards could also be enhanced by social marketing to communicate the meaning of that quality-assurance logo. The overall aim of that campaign would be to recognize the quality-assured products and use them instead of plain maize porridge, after 6 months of exclusive breastfeeding during transition to a safe and diverse family diet after 2 years of age, to complement continued breastfeeding alongside gradual introduction of nutrient-dense family foods.

7. Finally, the effectiveness of a new product standard could be documented through surveillance programs and household surveys. Rollout of social marketing could be randomized, to identify the effect of certification and sale of premixed cereals for infant feeding practices and child health outcomes.

REFERENCES

Abeshu, Motuma Adimasu, Azeb Lelisa, and Bekesho Geleta. 2016. “Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries – Lessons from Ethiopia.” *Frontiers in Nutrition* 3 (October). https://doi.org/10.3389/fnut.2016.00041.

Alamu, Emmanuel Oladeji, Therese Gondwe, Juliet Akello, Nancy Sakala, Grace Munthali, Mweshi Mukanga, and Busie Maziya-Dixon. 2018. “Nutrient and Aflatoxin Contents of Traditional Complementary Foods Consumed by Children of 6–24 Months.” *Food Science & Nutrition* 6 (4): 834–42. https://doi.org/10.1002/fsn3.621.

Bureau of the Fiscal Service. 2019. “Treasury Reporting Rates of Exchange - Current Rates.” U.S. Department of the Treasury. June 30, 2019. https://www.fiscal.treasury.gov/reports-statements/treasury-reporting-rates-exchange/current.html.

Campbell, Rebecca K, Kristen M Hurley, Abu Ahmed Shamim, Saijuddin Shaikh, Zaynah T Chowdhury, Sucheta Mehra, Lee Wu, and Parul Christian. 2018. “Complementary Food Supplements Increase Dietary Nutrient Adequacy and Do Not Replace Home Food Consumption in Children 6–18 Months Old in a Randomized Controlled Trial in Rural Bangladesh.” *The Journal of Nutrition* 148 (9): 1484–92. https://doi.org/10.1093/jn/nxy136.

Choudhury, Samira, Derek Headey, and William A. Masters. 2019. “First Foods: Diet Quality Among Infants Aged 6–23 Months in 42 Countries.” SSRN Scholarly Paper ID 3263020. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=3263020.

Christian, Parul, Saijuddin Shaikh, Abu Ahmed Shamim, Sucheta Mehra, Lee Wu, Maithilee Mitra, Hasmot Ali, et al. 2015. “Effect of Fortified Complementary Food Supplementation on Child Growth in Rural Bangladesh: A Cluster-Randomized Trial.” *International Journal of Epidemiology*, dyv155.

Clark, Lisa F, and Jill E Hobbs. 2018. “Informational Barriers, Quality Assurance and the Scaling up of Complementary Food Supply Chains in Sub-Saharan Africa.” *Outlook on Agriculture* 47 (1): 11–18. https://doi.org/10.1177/0030727018760601.

Cliffer, Ilana, William Masters, and Beatrice Rogers. 2019. “Displacement of Household Foods by Fortified Blended Flours versus Lipid-Based Supplements in Complementary Feeding of Children Aged 6–23 Months in Burkina Faso (OR21-03-19).” *Current Developments in Nutrition* 3 (Supplement_1). https://doi.org/10.1093/cdn/nzz034.OR21-03-19.

Collishaw, Anissa. 2017. “Willingness-to-Pay for a Small Quantity Lipid-Based Nutrient Supplement by Mothers of Young Infants in Malawi.” Ontario, Canada: The University of Guelph.

Dewey, Kathryn G. 2013. “The Challenge of Meeting Nutrient Needs of Infants and Young Children during the Period of Complementary Feeding: An Evolutionary Perspective.” *The Journal of Nutrition* 143 (12): 2050–54. https://doi.org/10.3945/jn.113.182527.

Dimaria, Sara, Hélène Schwartz, Christèle Icard-Vernière, Christian Picq, Noël Zagre, and Claire Mouquet-Rivier. 2018. “Adequacy of Some Locally Produced Complementary Foods Marketed in Benin, Burkina Faso, Ghana, and Senegal.” *Nutrients* 10 (6): 785. https://doi.org/10.3390/nu10060785.

Domijan, Ana-Marija. 2012. “Fumonisin B(1): A Neurotoxic Mycotoxin.” *Arhiv Za Higijenu Rada I Toksikologiju* 63 (4): 531–44. https://doi.org/10.2478/10004-1254-63-2012-2239.

EFSA Panel on Dietetic Products, Nutrition and Allergies. 2009. “Scientific Opinion on the Appropriate Age for Introduction of Complementary Feeding of Infants: Opinion on Complementary Feeding of Infants.” *EFSA Journal* 7 (12): 1423. https://doi.org/10.2903/j.efsa.2009.1423.

———. 2013. “Scientific Opinion on Nutrient Requirements and Dietary Intakes of Infants and Young Children in the European Union.” *EFSA Journal* 11 (10). https://doi.org/10.2903/j.efsa.2013.3408.

Egal, S., A. Hounsa, Y. Y. Gong, P. C. Turner, C. P. Wild, A. J. Hall, K. Hell, and K. F. Cardwell. 2005. “Dietary Exposure to Aflatoxin from Maize and Groundnut in Young Children from Benin and Togo, West Africa.” *International Journal of Food Microbiology* 104 (2): 215–24. https://doi.org/10.1016/j.ijfoodmicro.2005.03.004.

Faber, Mieke. 2005. “Complementary Foods Consumed by 6-12-Month-Old Rural Infants in South Africa Are Inadequate in Micronutrients.” *Public Health Nutrition* 8 (4): 373–81.

FAO, and WHO. 2017. “Standard for Processed Cereal-Based Foods for Infants and Young Children.” Codex Alimentarius International Food Standards. http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCODEX%2BSTAN%2B74-1981%252FCXS_074e.pdf.

Gama, A. P., and C. Ching’anda. 2015. “Hidden Salt in Breads of Blantyre (Malawi) and Labelling Practices: A National Wake-up Call.” *African Journal of Food, Agriculture, Nutrition and Development* 15 (5): 10443–54.

Geresomo, N. C., E. K. Mbuthia, J. W. Matofari, and A. M. Mwangwela. 2017. “Risk Factors Associated with Stunting among Infants and Young Children Aged 6 - 23 Months in Dedza District of Central Malawi.” *African Journal of Food, Agriculture, Nutrition and Development* 17 (04): 12854–70. https://doi.org/10.18697/ajfand.80.16730.

Gibson, R S, E L Ferguson, and J Lehrfeld. 1998. “Complementary Foods for Infant Feeding in Developing Countries: Their Nutrient Adequacy and Improvement.” *European Journal of Clinical Nutrition* 52 (10): 764–70. https://doi.org/10.1038/sj.ejcn.1600645.

Gibson, R. S., F. Yeudall, N. Drost, B. M. Mtitimuni, and T. R. Cullinan. 2003. “Experiences of a Community-Based Dietary Intervention to Enhance Micronutrient Adequacy of Diets Low in Animal Source Foods and High in Phytate: A Case Study in Rural Malawian Children.” *The Journal of Nutrition* 133 (11 Suppl 2): 3992S-3999S. https://doi.org/10.1093/jn/133.11.3992S.

Gong, Yun Yun, Sinead Watson, and Michael N. Routledge. 2016. “Aflatoxin Exposure and Associated Human Health Effects, a Review of Epidemiological Studies.” *Food Safety* 4 (1): 14–27. https://doi.org/10.14252/foodsafetyfscj.2015026.

Grosshagauer, Silke, Peiman Milani, Klaus Kraemer, Assumpta Mukabutera, Alexander Burkon, Marc Pignitter, Sebastian Bayer, and Veronika Somoza. 2019. “Inadequacy of Nutrients and Contaminants Found in Porridge-type Complementary Foods in Rwanda.” *Maternal & Child Nutrition*, June, e12856. https://doi.org/10.1111/mcn.12856.

Hell, K., C. Mutegi, and P. Fandohan. 2010. “Aflatoxin Control and Prevention Strategies in Maize for Sub-Saharan Africa.” *Julius-Kühn-Archiv; 425; 534-541*. https://doi.org/10.5073/jka.2010.425.388.

Hoffmann, Vivian, Kelly Jones, and Jef L. Leroy. 2018. “The Impact of Reducing Dietary Aflatoxin Exposure on Child Linear Growth: A Cluster Randomised Controlled Trial in Kenya.” *BMJ Global Health* 3 (6): e000983. https://doi.org/10.1136/bmjgh-2018-000983.

Hotz, C., and R. S. Gibson. 2001. “Complementary Feeding Practices and Dietary Intakes from Complementary Foods amongst Weanlings in Rural Malawi.” *European Journal of Clinical Nutrition* 55 (10): 841–49. https://doi.org/10.1038/sj.ejcn.1601239.
IFPRI Malawi. 2018. “Key Facts Sheet: Food and Nutrition Security.” IFPRI Malawi. http://massp.ifpri.info/files/2018/07/IFPRI_KeyFacts_Nutrition_100718_Final.pdf.
JECFA. 2016. “Fumonisins.” World Health Organization. 2016. http://apps.who.int/food-additives-contaminants-jecfa-database/chemical.aspx?chemID=2038.
Joseph, Michael, Sajid Alavi, and Quentin Johnson. 2017. “Complementary Foods and Global Fortification Challenges.” *The World of Food Ingredients*, February. https://foodaidquality.org/sites/default/files/publications/Complementary%20Foods%20Feb%202017.pdf.
Kalanda, B. F., F. H. Verhoeff, and B. J. Brabin. 2006. “Breast and Complementary Feeding Practices in Relation to Morbidity and Growth in Malawian Infants.” *European Journal of Clinical Nutrition* 60 (3): 401–7. https://doi.org/10.1038/sj.ejcn.1602330.
Kasapila, William, and Sharifudin Md. Shaarani. 2013. “A Survey of Nutrition Labelling on Packaged Foodstuffs Sold in Malawi: Manufacturer Practices and Legislative Issues.” *Food Control* 30 (2): 433–38. https://doi.org/10.1016/j.foodcont.2012.08.006.
Kerr, Rachel Bezner, Peter R. Berti, and Marko Chirwa. 2007. “Breastfeeding and Mixed Feeding Practices in Malawi: Timing, Reasons, Decision Makers, and Child Health Consequences.” *Food and Nutrition Bulletin* 28 (1): 90–99. https://doi.org/10.1177/156482650702800110.
Kiarie, Gideon, P Dominguez-Salas, SK Kang’ethe, D Grace, and J Lindahl. 2016. “Aflatoxin Exposure among Young Children in Urban Low-Income Areas of Nairobi and Association with Child Growth.” *African Journal of Food, Agriculture, Nutrition and Development* 16 (03): 10967–90. https://doi.org/10.18697/ajfand.75.ILRI02.
Kuchenbecker, J., I. Jordan, A. Reinbott, J. Herrmann, T. Jeremias, G. Kennedy, E. Muehlhoff, B. Mtimuni, and M. B. Krawinkel. 2015. “Exclusive Breastfeeding and Its Effect on Growth of Malawian Infants: Results from a Cross-Sectional Study.” *Paediatrics and International Child Health* 35 (1): 14–23. https://doi.org/10.1179/2046905514Y.0000000134.
Kumar, Pradeep, Dipendra K. Mahato, Madhu Kamle, Tapan K. Mohanta, and Sang G. Kang. 2017. “Aflatoxins: A Global Concern for Food Safety, Human Health and Their Management.” *Frontiers in Microbiology* 7 (January). https://doi.org/10.3389/fmicb.2016.02170.
Lartey, Anna, Alhassan Manu, Kenneth H. Brown, Janet M. Peerson, and Kathryn G. Dewey. 1999. “A Randomized, Community-Based Trial of the Effects of Improved, Centrally Processed Complementary Foods on Growth and Micronutrient Status of Ghanaian Infants from 6 to 12 Mo of Age.” *The American Journal of Clinical Nutrition* 70 (3): 391–404.
Leroy, Jef L., and Edward A. Frongillo. 2019. “Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence.” *Advances in Nutrition* 10 (2): 196–204. https://doi.org/10.1093/advances/nmy101.
Leroy, Jef L., Celeste Sununtnasuk, Armando García-Guerra, and Jia-Sheng Wang. 2018. “Low Level Aflatoxin Exposure Associated with Greater Linear Growth in Southern Mexico: A Longitudinal Study.” *Maternal & Child Nutrition* 0 (0): e12619. https://doi.org/10.1111/mcn.12619.
Leyvraz, Magali, Grant J. Aaron, Alia Poonawala, Marti J. van Liere, Dominic Schofield, Mark Myatt, and Lynnette M. Neufeld. 2017. “Coverage of Nutrition Interventions Intended for Infants and Young Children Varies Greatly across Programs: Results from Coverage Surveys in 5 Countries.” *The Journal of Nutrition* 147 (5): 995S-1003S. https://doi.org/10.3945/jn.116.245407.
Lombard, Martani J. 2014. “Mycotoxin Exposure and Infant and Young Child Growth in Africa: What Do We Know?” *Annals of Nutrition & Metabolism* 64 Suppl 2: 42–52. https://doi.org/10.1159/000365126.
Lutter, Chessa K., and Kathryn G. Dewey. 2003. “Proposed Nutrient Composition for Fortified Complementary Foods.” *The Journal of Nutrition* 133 (9): 3011S-20S. https://doi.org/10.1093/jn/133.9.3011S.
Maleta, K. 2003. “Timing of Growth Faltering in Rural Malawi.” *Archives of Disease in Childhood* 88 (7): 574–78. https://doi.org/10.1136/adc.88.7.574.
Masters, William A., John Kuwornu, and Daniel Sarpong. 2011. “Improving Child Nutrition through Quality Certification of Infant Foods: Scoping Study from a Randomized Trial in Ghana.” Working Paper 10/0828. London: International Growth Centre, London School of Economic and Political Science. http://www.theigc.org/node/1264.
Masters, William A., Marc D. Nene, and Winnie Bell. 2017. “Nutrient Composition of Premixed and Packaged Complementary Foods for Sale in Low- and Middle-Income Countries: Lack of Standards Threatens Infant Growth.” *Maternal & Child Nutrition* 13 (4): e12421. https://doi.org/10.1111/mcn.12421.
Matumba, Limbikani, Albert Chamango, and Wills Munthali. 2012. “Guidelines for the Management of Aflatoxin Contamination in Groundnuts and Maize in Malawi,” February, 32.
Matumba, Limbikani, M. Monjerezi, E. Chirwa, D. Lakudzala, and P. Mumba. 2009. “Natural Occurrence of AFB1 in Maize and Effect of Traditional Maize Flour Production on AFB1 Reduction in Malawi.” *African Journal of Food Science* 3 (12): 413–25.
Matumba, Limbikani, Maurice Monjerezi, Timothy Biswick, Jonas Mwatseteza, Wilkson Makumba, David Kamangira, and Alfred Mtukuso. 2014. “A Survey of the Incidence and Level of Aflatoxin Contamination in a Range of Locally and Imported Processed Foods on Malawian Retail Market.” *Food Control* 39 (May): 87–91. https://doi.org/10.1016/j.foodcont.2013.09.068.
Matumba, Limbikani, Christof Van Poucke, Maurice Monjerezi, Emmanuel Njumbe Ediage, and Sarah De Saeger. 2015. “Concentrating Aflatoxins on the Domestic Market through Groundnut Export: A Focus on Malawian Groundnut Value and Supply Chain.” *Food Control* 51 (May): 236–39. https://doi.org/10.1016/j.foodcont.2014.11.035.
Michaelsen, Kim F., Camilla Hoppe, Nanna Roos, Pernille Kaestel, Maria Stougaard, Lotte Lauritzen, Christian Mølgaard, Tsinuel Girma, and Henrik Friis. 2009. “Choice of Foods and Ingredients for Moderately Malnourished Children 6 Months to 5 Years of Age.” *Food and Nutrition Bulletin* 30 (3_suppl3): S343–404. https://doi.org/10.1177/15648265090303S303.
Michaud-Létourneau, Isabelle, Marion Gayard, and David Louis Pelletier. 2019. “Strengthening Advocacy and Policy Change for Infant and Young Child Feeding.” *Maternal & Child Nutrition* 15 Suppl 2: e12749. https://doi.org/10.1111/mcn.12749.

Monyo, E. S., S. M. C. Njoroge, R. Coe, M. Osiru, F. Madinda, F. Waliyar, R. P. Thakur, T. Chilunjika, and S. Anitha. 2012. “Occurrence and Distribution of Aflatoxin Contamination in Groundnuts (Arachis Hypogaea L) and Population Density of Aflatoxigenic Aspergilli in Malawi.” *Crop Protection* 42: 149–55.
Mosha, T.C.E., H.S. Laswai, and I. Tetens. 2000. “Nutritional Composition and Micronutrient Status of Home Made and Commercial Weaning Foods Consumed in Tanzania.” *Plant Foods for Human Nutrition* 55 (3): 185–205. https://doi.org/10.1023/A:1008116015796.
Mupunga, Innocent, Pamella Mngqawa, and David Katerere. 2017. “Peanuts, Aflatoxins and Undernutrition in Children in Sub-Saharan Africa.” *Nutrients* 9 (12): 1287. https://doi.org/10.3390/nu9121287.
Mwalwayo, Daniel S., and Bernard Thole. 2016. “Prevalence of Aflatoxin and Fumonisins (B1+B2) in Maize Consumed in Rural Malawi.” *Toxicology Reports* 3 (January): 173–79. https://doi.org/10.1016/j.toxrep.2016.01.010.
NSO, CHSU, CDC, and Emory University. 2017. “Malawi Micronutrient Survey Key Indicators Report 2015-16.” Atlanta, Georgia, USA: National Statistical Office (NSO), Community Health Sciences Unit (CHSU) [Malawi], Centers for Disease Control and Prevention (CDC), and Emory University. https://dhsprogram.com/pubs/pdf/FR319/FR319.m.final.pdf.
NSO, and ICF. 2017. “Malawi Demographic and Health Survey 2015-16.” Zomba, Malawi and Rockville, MD, USA: National Statistical Office (NSO) and ICF.
Olney, Deanna K., Jef Leroy, Lilia Bliznashka, and Marie T. Ruel. 2018. “PROCOMIDA, a Food-Assisted Maternal and Child Health and Nutrition Program, Reduces Child Stunting in Guatemala: A Cluster-Randomized Controlled Intervention Trial.” *The Journal of Nutrition* 148 (9): 1493–1505. https://doi.org/10.1093/jn/nxy138.
Owino, V., B. Amadi, M. Sinkala, S. Filteau, and A. Tomkins. 2008. “Complementary Feeding Practices And Nutrient Intake From Habitual Complementary Foods Of Infants And Children Aged 6-18 Months Old In Lusaka, Zambia.” *African Journal of Food, Agriculture, Nutrition and Development* 8 (1): 28-47–47.
PACA. 2018. “Strengthening Aflatoxin Control in Malawi: Policy Recommendations.” Partnership for Aflatoxin Control in Africa.
Panjwani, Anita, and Rebecca Heidkamp. 2017. “Complementary Feeding Interventions Have a Small but Significant Impact on Linear and Ponderal Growth of Children in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis.” *The Journal of Nutrition* 147 (11): 2169S-2178S. https://doi.org/10.3945/jn.116.243857.
Phuka, John C., Kenneth Maleta, Chrissie Thakwalakwa, Yin Bun Cheung, André Briend, Mark J. Manary, and Per Ashorn. 2008. “Complementary Feeding with Fortified Spread and Incidence of Severe Stunting in 6- to 18-Month-Old Rural Malawians.” *Archives of Pediatrics & Adolescent Medicine* 162 (7): 619–26. https://doi.org/10.1001/archpedi.162.7.619.
Roess, Amira A, Emma F Jacquier, Diane J Catellier, Ryan Carvalho, Anne C Lutes, Andrea S Anater, and William H Dietz. 2018. “Food Consumption Patterns of Infants and Toddlers: Findings from the Feeding Infants and Toddlers Study (FITS) 2016.” *The Journal of Nutrition* 148 (suppl_3): 1525S-1535S. https://doi.org/10.1093/jn/nxy171.
Smith, Laura E., Andrew J. Prendergast, Paul C. Turner, Mduduzi N. N. Mbuya, Kuda Mutasa, George Kembo, and Rebecca J. Stoltzfus. 2015. “The Potential Role of Mycotoxins as a Contributor to Stunting in the SHINE Trial.” *Clinical Infectious Diseases* 61 (suppl 7): S733–37. https://doi.org/10.1093/cid/civ849.
Smith, Laura E., Rebecca J. Stoltzfus, and Andrew Prendergast. 2012. “Food Chain Mycotoxin Exposure, Gut Health, and Impaired Growth: A Conceptual Framework1.” *Advances in Nutrition* 3 (4): 526–31. https://doi.org/10.3945/an.112.002188.
Stephenson, Kevin B., Sophia E. Agapova, Oscar Divala, Yankho Kaimila, Kenneth M. Maleta, Chrissie Thakwalakwa, M. Isabel Ordiz, Indi Trehan, and Mark J. Manary. 2017. “Complementary Feeding with Cowpea Reduces Growth Faltering in Rural Malawian Infants: A Blind, Randomized Controlled Clinical Trial.” *The American Journal of Clinical Nutrition* 106 (6): 1500–1507. https://doi.org/10.3945/ajcn.117.160986.
U.S. Government Accountability Office. 2008. “Food Labeling: FDA Needs to Better Leverage Resources, Improve Oversight, and Effectively Use Available Data to Help Consumers Select Healthy Foods,” no. GAO-08-597 (October). https://www.gao.gov/products/GAO-08-597.
USDA. 2009. “Nutritional Needs of Infants.” In *Infant Nutrition and Feeding: A Guide for Use in the WIC and CSF Programs*. United States Department of Agriculture Food and Nutrition Service. https://wicworks.fns.usda.gov/wicworks/Topics/FG/Chapter1_NutritionalNeeds.pdf.
Vaahtera, M., T. Kulmala, A. Hietanen, M. Ndekha, T. Cullinan, M.-L. Salin, and P. Ashorn. 2001. “Breastfeeding and Complementary Feeding Practices in Rural Malawi.” *Acta Pædiatrica* 90 (3): 328–32. https://doi.org/10.1111/j.1651-2227.2001.tb00313.x.
Victora, Cesar Gomes, Mercedes de Onis, Pedro Curi Hallal, Monika Blössner, and Roger Shrimpton. 2010. “Worldwide Timing of Growth Faltering: Revisiting Implications for Interventions.” *Pediatrics* 125 (3): e473-480. https://doi.org/10.1542/peds.2009-1519.
Webb, Patrick, Beatrice Rogers, I. Rosenberg, N. Schlossman, C. Wanke, J. Bagriansky, K. Sadler, et al. 2011. “Delivering Improved Nutrition: Recommendations for Changes to U.S. Food Aid Products and Programs.” Boston, MA: Tufts University. https://reliefweb.int/sites/reliefweb.int/files/resources/DeliveringImprovedNutrition.pdf.
WFP. n.d. “Technical Specifications for the Manufacture of: SUPER CEREAL CORN SOYA BLEND with SUGAR.” World Food Programme.
WHO. 2010. *Indicators for Assessing Infant and Young Child Feeding Practices: Part III - Country Profiles*. Vol. Part 3: Country Profiles. Washington, D.C.: World Health Organization (WHO).
———. 2018. “Aflatoxins.” World Health Organization Department of Food Safety and Zoonoses. http://www.who.int/foodsafety/Food_Safety_Digest_Aflatoxins_EN.pdf.
Zlotkin, Stanley. 2006. “A Critical Assessment of the Upper Intake Levels for Infants and Children.” *The Journal of Nutrition* 136 (2): 502S-506S. https://doi.org/10.1093/jn/136.2.502S.

About the Authors

Rachel Gilbert is a Leland International Hunger Fellow working in the Development Strategy and Governance Division of the International Food Policy Research Institute in Washington, DC and with the Malawi Strategy Support Program.

Binita Subedi is a master's candidate in the Food Policy and Applied Nutrition program at the Friedman School of Nutrition Science and Policy at Tufts University.

Jessica K. Wallingford is a master's candidate in the Agriculture, Food and Environment program at the Friedman School of Nutrition Science and Policy at Tufts University.

Norbert Wilson is a Professor at the Friedman School of Nutrition Science and Policy.

William A. Masters is a Professor at the Friedman School of Nutrition Science and Policy, with a secondary appointment in Tufts University's Department of Economics.

Acknowledgments

The authors would like to thank Ric Bayly for his work as a research assistant on this project. The authors would also like to thank Todd Benson for his time and careful review of this paper.

Funding

This project was supported by United States Department of Agriculture (USDA) award # TA-CA_15_008 to Tufts University.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

1201 Eye Street, NW | Washington, DC 20005-3915 USA
T: +1.202.862.5600 | F: +1.202.862.5606
Email: ifpri@cgiar.org | www.ifpri.org

IFPRI-Lilongwe

P.O. Box 31666 | Lilongwe 3, Malawi
T +265-1-771780 | Email: ifpri-lilongwe@cgiar.org

The Malawi Strategy Support Program (MaSSP) is managed by the International Food Policy Research Institute (IFPRI) and is financially made possible by the UK Department of International Development (DFID) and the generous support of the American people through the United States Agency for International Development (USAID). This publication has been prepared as an output of MaSSP. It has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and do not necessarily reflect those of IFPRI, USAID, DFID, or CGIAR.