

Mallory Bowers

Tippecanoe Valley High School

Akron, Indiana

Malawi: Factor - Malnutrition

Biofortification to Meet Micronutrient Needs of Malawians

Malawi, a landlocked country in southeast Africa, is 45,747 square miles with an approximate population of 18.6 million (World Atlas, n.d.). Malawi is comparable in size to Mississippi and Pennsylvania. According to the Food Security Index, Malawi is the 7th most food insecure country in the world. There are a multitude of factors that affect food security in Malawi including corruption, the lack of presence of food safety net programs, low diet diversification, inadequate protein quality, and poor micronutrient availability. The Malawians also have issues with too low public expenditure on agriculture research and development, have an extremely low gross domestic product per capita and have a large percentage of their population living below the poverty line.

The average people per household in Malawi is 4.4 (Bauer, 2016). Nearly 65% of the population live in traditional housing, defined as a dwelling with mud walls and a thatched roof. About 16% live in permanent structures made with concrete, stone, or burnt brick walls (Nations Encyclopedia, n.d.). Approximately 18% lived in semi-permanent dwellings built with a combination of concrete, stone, mud brick and thatch (Nations Encyclopedia, n.d.). Most dwellings have two to three rooms, but only 2.5% of dwellings have access to indoor piped water (Nations Encyclopedia, n.d.). The Malawians that do not have access to water in their dwelling get their water from boreholes, unprotected wells, rivers or streams (Nations Encyclopedia, n.d.). 84% of the population lives in rural locations, leaving 16% in urban areas. Between the two, about 74% use pit latrines, and about 22% live without toilets (Nations Encyclopedia, n.d.). Only approximately 4.9% of the population has access to electricity, so the wood is used for cooking fuel and paraffin is used for lighting (Nations Encyclopedia, n.d.).

Malawi government healthcare is provided for free in three forms: health centers at the local level, regional/rural hospitals one level up, and district hospitals at the highest level ("General Information", 2019). Primary education is free for families, but they still have to buy school supplies. Since the early 2000s, Malawi's government has made good hygiene, clean water, and decent toilets for every person top priorities. Now, two in three people have clean water to drink and fewer people than in the past have to use the bathroom in the open (WaterAid, n.d.). More than 3,100 children under five die from diarrhea each year due to dirty water and poor toilets (WaterAid, n.d.).

Malawi is located south of the equator and is mostly hilly and mountainous with a tropical climate. From mid-November to April they have a hot, very rainy season, and from May to mid-August a cool, dry season. From September to November, before the rainy season, temperatures rise to the highest points of the year (“Climate - Malawi”, n.d.). The highways are not in the best condition and roads closer to rural areas are very beat up. With the rainy weather and not having the money to fix the roads, they continue to get worse making the distribution of food more difficult.

Malawi has a multiparty republic government with a president and vice president. One of the main departments in the Malawian government is the Ministry of Agriculture, Irrigation and Water Development. This ministry is extremely important in contribution to the economy and is active in the society in general (Minister of Agriculture, 2016). The Ministry has seven technical departments: Agriculture Extension Services, Crops Development, Animal Health and Industry, Agriculture Resources, Agriculture Planning Services, Land Resource and Conservation, and Fisheries. The government responsible for the water sub-sector, Irrigation and Water Development, is also included in the Ministry. The Minister of Agriculture and Irrigation is Mr. Allen Chiyembekeza. The government provides a subsidy program called the Farm Input Subsidy (FISP). In the program, they distribute vouchers to smallholder farmers that are landowners so they can buy fertilizer, pesticides, and hybrid seeds for discounted prices (Fisher & Chibwana, 2011). About 20% of public expenditures was spent by Malawi in support of food and agriculture in 2013 (FAO, 2014).

In Malawi, the most successful sector that competes with international markets is Agriculture. Malawi’s most important cash crops are tobacco, coffee, tea, and sugar. Also, exporters have started growing groundnuts and macadamia nuts successfully (“Malawi-Agriculture Sector”, 2017). 49% of Malawi is agricultural land and approximately 2% of the cropland is irrigated (“Malawi”, 2018). More than 80% of the country’s export earnings are from agriculture, specifically tobacco, tea and sugar (“Malawi”, 2018). Tobacco, tea, sugar, and coffee are the most important cash crops, most anything else is raised for themselves (“Malawi Agriculture Sector”, 2017). Approximately 11 million people are subsistence farmers, meaning they primarily produce food for themselves (Manda & Makowa, 2012). There is 700,000 head of beef in Malawi and the population is slowly decreasing (Chintsanya et al., 2019). The pig population has increased from 250,000 in 1994 to 420,000 in 1997 (Chintsanya et al., 2019). There is about 200,000 head of sheep and they are slowly increasing. The population of goats is steady, with approximately 1.2 million (Chintsanya et al., 2019). There is a large population of chickens, having 12 million, and a plentiful amount of turkeys, ducks, guinea fowl, and pigeons (Chintsanya et al., 2019). Livestock plays an important role in providing essential proteins.

Some of the more common traditional foods in Malawi are Nsima, a form of maize porridge, and Mkhwani, a relish made from pumpkin leaves and peanut flour, which is a side dish for Nsima (“Best Local”, 2017). A couple of other common Malawian foods are Mgaiwa Phala, a type of ground corn, and Kachumbari, a mix of onions, tomatoes, and spicy chili peppers (“Best Local”, 2017). On the east side of Malawi, bordered by Lake Malawi, they also eat a lot of fresh fish dishes. To cook these dishes, many use wood for cooking fuel and paraffin for lighting due to the lack of access to electricity. Corn or maize is easily the most common staple food, as well as other starchy foods such as cassava, but these lack many important micronutrients.

Malawi is mainly a rural, agricultural country. Some current forms of agricultural practices combined with environmental degradation and unpredictable weather, reduce food production and harm the resources of smallholder farmers. To combat food security, Malawi’s government has formed a National Nutrition Policy and Strategic Plan similar to the Comprehensive Africa Agriculture Development Program’s (CAADP) investment plan. The plan is titled the Agriculture Sector-Wide Approach (ASWAp) in Malawi. Together the programs strive to organize food security and nutrition programming on national and community levels. Due to a lack of understanding about the importance of food diversity, what is available locally and the seasonal unavailability in Malawi, there is increasing poor food diversification. All of this results in family diets that don't include the six food groups recommended every single day, which can lead to micronutrient deficiencies (FAO, 2019).

One of the largest issues the Malawi population suffers from is malnutrition. Beyond just a lack of food, often times the food they have is deficient in specific micronutrients. Many are deficient in iron, the percentage being higher in urban areas (50% respectively) than in rural areas (19% respectively) (National Statistical Office et al., 2016). Iron deficiency is also higher in males with about 26% than females with about 26% (National Statistical Office et al., 2016). In school-aged children, iron deficiency is as low as approximately 5%, but in preschool children, it is about 9% (National Statistical Office et al., 2016). Anemia, caused by iron deficiency, is also found in nearly one in five school-aged children and one in three preschool children (National Statistical Office et al., 2016). Vitamin A deficiency is relatively low, at approximately 4% in preschool children, and less than 1% in school-aged children, men, and women of reproductive age (National Statistical Office et al., 2016). However, in Malawi, the zinc deficiency level is very concerning. With about 60% of preschool children and school-aged children being deficient, the lack of zinc leads to many child deaths (National Statistical Office et al., 2016). Also, the women of reproductive age have a zinc deficiency of about 62.5%, potentially leading to unhealthy pregnancies (National Statistical Office et al., 2016).

Iron and zinc deficiencies are both pressing issues that need to be resolved. For the purposes of this paper, I am focusing on zinc deficiency. My proposed solution is using biofortification in

corn to increase zinc consumption in staple food. The orange-fleshed sweet potato (OFSP) is a successful example of using biofortification to reduce a micronutrient deficiency. The OFSP was developed by Dr. Maria Andrade of Cape Verde, Dr. Robert Mwangi of Uganda, and Dr. Jan Low of the United States. Dr. Andrade and Dr. Mwangi raised Vitamin A enhanced OFSP while Dr. Low constructed nutrition studies and structured programs that were able to convince approximately two million households in ten different African countries to raise, purchase and devour this nutrition packed food (Andrade, Low, Mwangi, & Bouis, 2016). The development of the OFSP was a major achievement, but education and marketing was an essential piece to actually get people to raise and consume it.

I envision a similar project with corn, but instead of focusing on Vitamin A, focusing on Zinc. While much emphasis has been placed on improving Vitamin A and Iron, not as much focus has been placed on Zinc even though it causes many health issues. In a 2018 paper by Muhammad Amir Maqbool and AbduRahman Behsir's they state that " biofortification is most impactful, convenient, sustainable, and acceptable intervention." Maize is one of the most common food sources across Malawi, and by biofortifying to have increased levels of Zinc, consumption of this important nutrient can be increased. Through genetic and agronomic approaches the concentration of Zinc in maize can be increased, just as researchers have shown possible with Vitamin A in maize. With any Zinc biofortification process that includes maize, Zinc has to first be present in the soil. If farmers were to use fertilizer to make sure the soil had adequate levels of Zinc and a biofortified maize was developed to utilize and store Zinc at higher levels, it is possible that it could be used to provide Malawians a healthy amount of Zinc in an efficient manner. Some research has already been conducted, showing the real possibility for a Zinc biofortified maize to be produced.

I propose a joint effort from the Ministry of Agriculture, Irrigation, and Water Development, Purdue University and the Bill and Melinda Gates Foundation. Using Purdue's laboratories to conduct the studies and experiments of biofortifying maize to have higher concentrations of Zinc, and the Ministries ability to communicate with their villages, this could be a life-saving solution. Obviously, this would need funding, and given Bill and Melinda Gate's willingness to fund development of golden rice, I believe this would be a good place to apply for funding. The FISP program can be used to provide farmers with subsidies to purchase the correct fertilizer.

Dr. Low, Dr. Mwangi, and Dr. Andrade were successful because not only did they accomplish biofortifying the orange-fleshed sweet potato, but they also communicated and convinced the villages to attempt to produce and consume the product. This effort led families to increase their intake of Vitamin A. By going to villages and teaching farmers how to farm the biofortified maize and what the benefits are, it would be possible to convince them to raise this maize. With a

concerted effort to educate the public about health issues caused by low Zinc, subsistence farmers may be more likely to switch over to this new biofortified maize product.

Communication and education play a large part in any solution, but it is extremely important in this one. If maize is successfully biofortified to produce more Zinc but Malawians are not educated about it, adoption of it will be low. Specifically, I would again point to the work by Dr. Low with the orange-fleshed sweet potato. This would include a three prong approach. The first component would focus on production of the biofortified crop. Scientists would help farmers plant multiple test plots and give lessons on how to raise and harvest them. They would also show them new ways to store their crops to improve the quality of the crops. The second component would focus on education of consumers, teaching about the added nutritional value and benefits of consumption of this biofortified maize. Finally, the last part would focus on working with buyers to develop a strong market and producers to identify these selling points. This model was very effective for Low and I believe could work for biofortified maize, as the situation is very similar.

Accomplishing successful biofortified maize can be done by genetically modifying maize to have increased levels of Zinc retained in kernels, or it can be done using natural breeding methods by selecting for varieties that have higher amounts. Either way, there still has to be Zinc available in the soil, or the biofortification process will not work. The benefit of using genetic engineering to develop this new variety is that it may be able to be developed faster. The faster this new biofortified crop can get to farmers, the quicker Zinc deficiency can begin to be reduced. One of the drawbacks of using genetic engineering is they may not be allowed to grow a genetically engineered crop due to government regulations. Also, the population might not want to grow genetically engineered crops even if allowed and it is costly to develop. Of course, producing Zinc biofortified maize could be attempted through traditional breeding methods or gene editing. Traditional breeding methods may prove to be a slower process, even if it is more accepted. On the other hand, gene editing may provide a quick option that doesn't have to clear the regulatory hurdles of a genetically engineered crop.

Malawi is one of a handful of countries in Africa in a position to begin commercializing genetically modified crops. Cotton, cowpeas, and bananas are now in field trials. The Biosafety act was passed in 2002 and Biosafety regulations were passed in 2007 (Chaweza, 2017). In 2008 the National Biosecurity and Biosafety Policy was enacted (Chaweza, 2017). Now, a completely functional committee for biosafety regulatory has been established to thoroughly go through applications for trials. Genetically modified cotton is already at the variety registrational stage. Genetically modified cowpea is in its second year of confined field trials, and the virus resistant banana is on its first year of confined field trials. The fact that a framework is in place and field

trials are already underway for other crops, should allow for easier approval and adoption of genetically modified biofortified maize crop.

In conclusion, malnutrition is a major concern in Malawi. They are extremely deficient in Zinc, as it is about 36% higher than any other deficiency. My proposed solution is to create a new variety of maize that is biofortified to provide higher levels of Zinc, with the end goal being to decrease the national level of a serious micronutrient deficiency.

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