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Assessing the Potential Adoption of Quinoa for Human Consumption in Central Malawi

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This study assesses the potential adoption of quinoa for consumption in central Malawi. Environmental, economic, and social problems are prevalent in this region dependent on subsistence agriculture. Quinoa is conceptualized as a new agricultural innovation. If successfully adopted, quinoa may have the potential to provide additional nutrition, crop diversification, and added value as an export crop for smallholder farms. Everett Rogers' Diffusion of Innovations framework seeks to explain how, why, and at what rate individuals or societal groups adopt new ideas and technology over time. To assess the potential adoption of quinoa as an alternative food source in central Malawi, this exploratory study focuses on two aspects of the Diffusion of Innovations model: perceived compatibility (an innovation attribute) and change agents' promotion efforts. With an emphasis on the local-level experiences of regional farmers and extension specialists, data were gathered to evaluate the adoption potential of a new innovation (quinoa) and the potential diffusion of information between extension programs and local farmers. Results showed that adoption potential in this region is positive, with a focus on regular and consistent extension visits, and participatory research between researchers, extension, and villagers.

Keywords: quinoa, adoption, diffusion, extension, nutrition

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INTRODUCTION

More than one third of Africa's population is considered food insecure, and the number of people facing hunger rises each year (Simtowe et al., 2010). Food security is defined as access by "all people at all times to enough food for an active, healthy life … food insecurity exists whenever food security is limited or uncertain" (Campbell, 1991). Located in southeastern Africa, Malawi is a country facing rising population, declining soil fertility, malnutrition, and poverty. In Malawi, agriculture accounts for 90% of the food supply, provides 80% of the employment, and contributes 40% of the gross domestic product (Simtowe et al., 2010). Further, the majority of Malawian households rely on their own agricultural production to meet household food needs, with maize as the primary staple. Food insecurity and malnutrition are persistent problems experienced by people living in poor households in central Malawi (Simtowe et al., 2010), with close to one-third of all households in Malawi suffering from severe food insecurity and calorie deficiencies (Ecker and Qaimm, 2011).

Malawi is a predominantly rural country, where ∼80% of the population live in villages with <1,000 people (Benson et al., 2002). Of the 70% of the people who live below the poverty line, most dwell in rural areas (World Bank, 2014). Unpredictability in rainfall and lack of access to improved technologies in agriculture have resulted in sub-optimal levels of food availability. In addition, low levels of income among subsistence farmers reduce the accessibility to food during periods of scarcity. Livelihoods that depend on agriculture are vulnerable to many stressors and shocks including drought, flooding, disease, and malnutrition. Under these circumstances, the need to promote adoption of new agricultural technologies is paramount (Masangano and Miles, 2004). According to the Food and Agriculture Organization (FAO) of the United Nations, one of the interventions to address these issues is the introduction of new crops (FAO, 2007). Using annual and semi-perennial legume mixtures in maize-based crop systems, Snapp et al. (2010) provided evidence that crop diversification in Africa could be effective in achieving higher grain yields per hectare, and improving yield stability and food security on a countrywide scale.

Adoption and use of agroecological strategies are positively lined to household well-being and human health in semi-humid tropical Malawi (Nyantakyi-Frimpong et al., 2017). These agroecological methods include the cultivation of a diverse range of crops, thereby contributing to food security and dietary diversity (Jones et al., 2014). Challenges such as malnutrition and crop failures can potentially be met through promoting new varieties of a staple food crop such as quinoa (*Chenopodium quinoa* Willd). With its high nutritional content and adaptability to harsh growing conditions, quinoa may have the potential to diversify crops on smallholder farms and to supply an extra source of nutrition to subsistence farmers (Jacobsen et al., 2003; Sun et al., 2014; Peterson and Murphy, 2015; Walters et al., 2016; Wu et al., 2016; Jarvis et al., 2017; Hinojosa et al., 2018, 2019; Murphy et al., 2019).

Quinoa is celebrated for its excellent nutritional quality and potential to improve global food security (Wu et al., 2017; Noratto et al., 2019). Quinoa is also rich in vitamins and minerals, with more calcium, phosphorus, magnesium, potassium, iron, copper, manganese, and zinc than wheat, barley or corn (Comai et al., 2007). Quinoa seed is richer in lipids than most cereal grains including wheat, rice, barley, maize, oat, and rye. Lipid content of quinoa generally ranges from 5.0 to 7.2% and is a good source of essential fatty acids (Vega-Gálvez et al., 2010). Most critical to addressing the problem of national and global malnutrition and hidden hunger, quinoa seed has been reported to contain a well-balanced and significant amount of the nine essential amino acids required to fulfill our daily protein requirement (Vega-Gálvez et al., 2010).

Quinoa was first introduced to Africa in the late 1990s in Ethiopia and Kenya (Oyoo et al., 2010) and more recently in Malawi (Maliro and Guwela, 2015; Maliro et al., 2017). Eleven quinoa varieties were evaluated for yield and agronomic characteristics at the Bunda College's Horticulture Research Farm and Bembeke Agricultural Sub Research Station in Malawi in 2012 and 2013. The highest yielding variety tested under rainfed conditions at Bunda was "Black Seeded," which yielded approximately 2,050 kg/ha. Under irrigated conditions at Bunda, the highest yielding variety, "Titicaca" produced approximately 3,019 kg/ha of seed (Maliro et al., 2017). Seed varieties and breeding populations are becoming more widely available and accessible to farmers and researchers in non-traditional quinoa growing regions worldwide; therefore, with further testing and focused breeding efforts, quinoa seed yield in Malawi is expected to increase over these preliminary results (Bazile et al., 2013; Murphy et al., 2016).

The potential for the continued successful introduction and production of quinoa in African farming systems is considerable (Maliro and Guwela, 2015; Maliro et al., 2017). Different ecotypes and varieties of quinoa are adapted to a wide range of climates and ecological zones in its center of diversity, the Andean region of South America, and these can be tested throughout different mega-environments of Africa. In addition to contributing to its own food security, Malawi and other countries in Africa can potentially take advantage of the growing world demand to produce quinoa for export (Jayne et al., 2003).

Drawing on in-depth qualitative field research and Rogers (2003) Diffusion of Innovations framework, this exploratory research examines the adoption potential of quinoa consumption in central Malawi. We ask three primary research questions: (1) If quinoa was grown successfully in central Malawi, would it be accepted as a new food by the local population? (2) What role does perceived compatibility with sociocultural beliefs, practices, and needs play in the adoption potential of quinoa consumption? (3) What role do change agents' promotion efforts play in the adoption potential of quinoa consumption?

CONCEPTUAL FRAMEWORK

The adoption of appropriate innovations is an important issue in agricultural development. Evaluating the factors that may influence the potential adoption of a new innovation is vital when working in agricultural systems such as those present in Malawi. The Diffusion of Innovations framework, developed over a half century ago, has long been popular for explaining how new ideas and technologies are dispersed and adopted across and within a community (Rogers, 2003).

The Diffusion of Innovations is a theory that seeks to explain how, why, and at what rate individuals or societal groups adopt new ideas and technology over time. The major argument for the Diffusion of Innovations model is that access to information about an innovation is the key factor in determining adoption decisions. According to Rogers (2003), five different variables determine the rate of adoption of innovations: (1) perceived innovation attributes (relative advantage, compatibility, complexity, trialability, and observability), (2) type of innovation-decision, (3) communication channels, (4) nature of the social system, and (5) extent of change agents' promotion efforts. While all five variables are important in assessing the potential for the adoption of an innovation, our research focuses specifically on perceived compatibility (an innovation attribute) and the extent of change agents' promotion efforts.

"Compatibility" is "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 2003, p. 240). If potential adopters perceive an innovation to be compatible with sociocultural values and beliefs, previously introduced ideas, or felt needs, then they are more likely to adopt the innovation. Perceived compatibility helps individuals "give meaning" to new ideas so they seem "more familiar" (Rogers, 2003, p. 240).

Another important predictor of an innovation's rate of adoption is the extent of change agents' promotion efforts. Rogers (2003, p. 27) defines a "change agent" as "an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency." Change agents include agricultural extension agents, development workers, salespeople, teachers, and public health workers (Rogers, 2003). Change agents "usually possess a high degree of expertise regarding the innovations that are being diffused" (Rogers, 2003, p. 368). The promotional and educational efforts put forth by change agents can either impede or speed up the adoption of an innovation. One of the main roles of a change agent is to facilitate the flow of innovations (or information about innovations) from a change agency to a particular group of clients (or potential adopters).

Some change agents are relatively more successful than others in influencing clients' innovation-decisions. Rogers (2003) describes four factors that determine a change agent's success: (1) change agent effort (i.e., communication with clients), (2) client orientation (i.e., rapport with clients), (3) compatibility with clients' needs (i.e., awareness of clients' felt needs), and (4) change agent empathy. Our study focuses specifically on change agent effort and compatibility with clients' needs.

The change agents in our study include outreach and extension personnel associated with the Bunda College of Agriculture (BCA), Total Landcare (TLC), and the Extension Planning Area (EPA) office near BCA. Located on the outskirts of the capital city of Lilongwe, BCA is one of the five colleges that constitute the University of Malawi. Founded in Malawi in 1999, TLC is a non-profit, non-government organization that focuses on improving the livelihoods of smallholder farmers. TLC is affiliated with Washington State University (WSU) through a memorandum of agreement that directs TLC to facilitate the implementation of WSU-led projects in Malawi. The EPA office near BCA is one of nearly 200 sub-district offices of Malawi's Ministry of Agriculture. The EPA offices promote and accelerate sustainable agricultural development and education.

MATERIALS AND METHODS

Fieldwork was conducted in July–August 2012 during the dry season in central Malawi (**Figure 1**) in an exploratory effort to gain insight into agronomic practices, daily food intake, perceptions of new foods, and social dynamics. The overall research design was based on qualitative analysis and grounded theory. Qualitative analysis involves obtaining an in-depth understanding of human behavior and the reasons surrounding or causing that behavior (Creswell et al., 2003). Grounded theory is used as a means for identifying, categorizing, and conceptualizing themes that emerge from interviews, focus group discussions, and other research activities. Grounded theory assists researchers in creating "conceptual understandings from concrete realities" that are grounded in gathered data (Charmaz, 2003, p. 311).

Research methods included 21 semi-structured interviews and one group observation. With the assistance of BCA staff and students and the local governmental extension outreach office, potential interviewees were identified at BCA, in eight villages surrounding BCA, and in local governmental extension offices. Snowball sampling was used to build the list of potential interviewees. Choosing a diverse group of interviewees in terms of economic status, gender, age, geographic location, and other demographic characteristics maximized the heterogeneity of the sample. Data collection tools included separate questionnaire forms for villagers and change agency (extension) personnel. A local interpreter was used when language barriers existed. Interviews with villagers took place near or at interviewees' homes. Interviews with change-agency personnel took place in BCA classrooms or open courtyards, the TLC office in Lilongwe, and the EPA office. All interviews were audio recorded (with interviewees' consent) and anonymity was maintained. Audio interviews were then transcribed and analyzed.

A group observation involving 12 individuals (eight men and four women) was conducted at the TLC office in the capital of Lilongwe. The group observation took place during the lunch hour at TLC in an open courtyard behind the building. The lunch consisted of *nsima*, vegetable relishes, chicken, and a side of quinoa. *Nsima* is a sturdy, white paste made by combining maize flour or cassava with boiling water. Featured in most Malawi meals, the *nsima* patty is often used as a utensil to "grab" additional plate relishes. *Nsima* is balled in the right hand, dipped in *ndiwo* (a sauce or condiment), and eaten. Depending on the time of year and food availability, *ndiwo* may be made of fish, meat, beans, greens, or other ingredients. Provided for the purposes of our study, the quinoa was prepared, similar to rice, on a traditional three-stone hearth by two Malawian women (employed by TLC) who regularly prepare lunch for TLC employees. The quinoa took ∼20 min to cook. Observation notes were taken as groups of three to four TLC employees ate the cooked quinoa as part of their lunch. Participants were also asked to provide comments about how the quinoa tasted.

Based on the Exemption Determination Application submitted for the study titled "The social acceptability of quinoa as a supplement in the Malawian diet," and assigned IRB #12630, the WSU Office of Research Assurances determined that the study satisfies the criteria for Exempt Research at 45 CFR 46.101(b)(2) and 45 CFR 46.101(b)(6), and therefore, that this study may be conducted according to the protocol described in the Application without further review by the IRB. Written informed consent was not obtained because it was determined that the majority of study participants were unable to read or write. Verbal consent was provided for the publication of all the information except for age of the individual. Therefore, ages of an individual presented in this manuscript were done so using a 5-year age range.

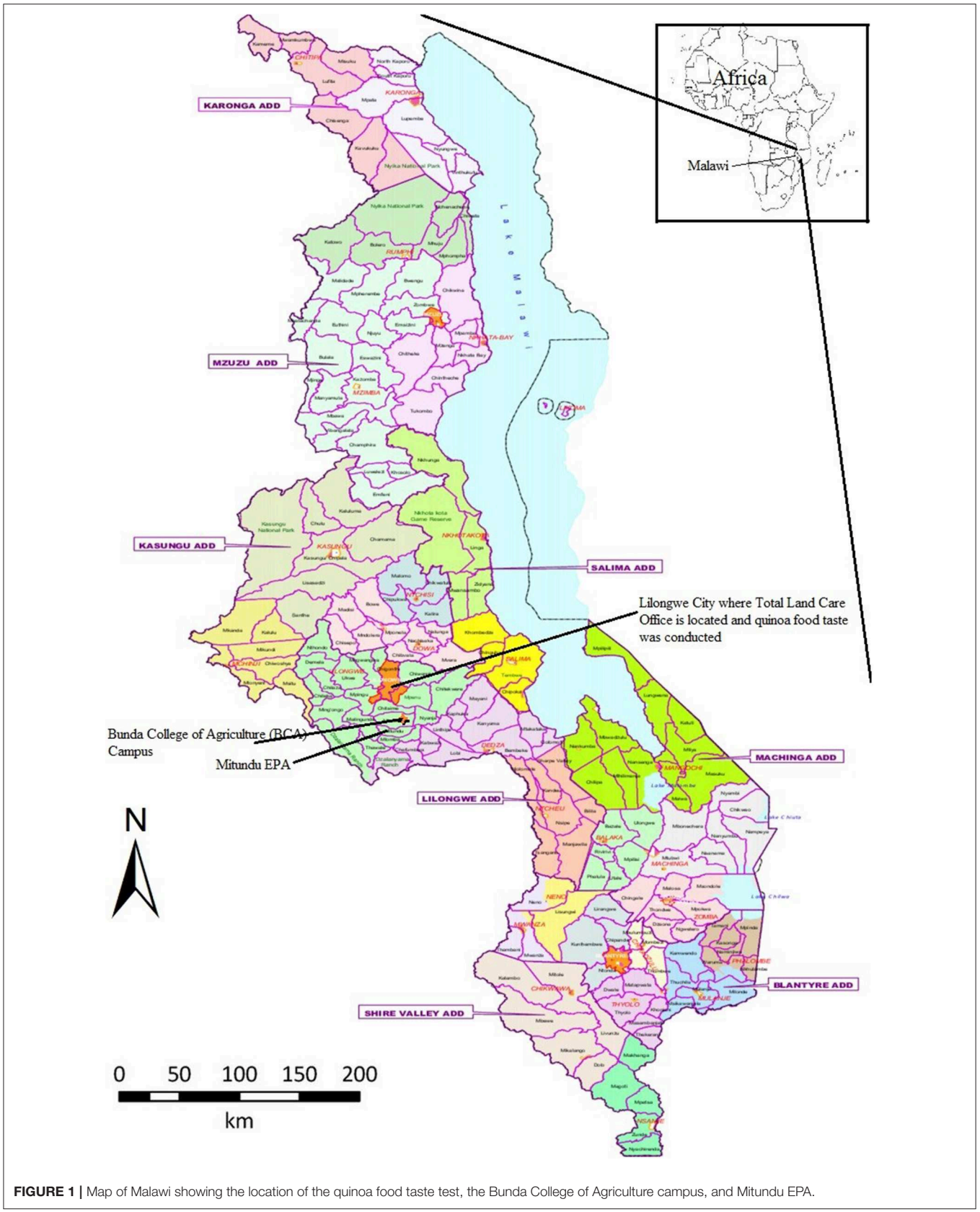

FIGURE 1 | Map of Malawi showing the location of the quinoa food taste test, the Bunda College of Agriculture campus, and Mitundu EPA.

TABLE 1 | Socio-demographic characteristics of village interviewees in central Malawi near the Bunda College of Agriculture ($N = 16$).

Characteristic	Categories	Percentage (%)	*N*	Average
Gender	Male	25	4	n/a
	Female	75	12	
Age (years)	n/a	n/a	16	39.7
Marital status	Married	69	11	
	Widowed	31	5	
Education	None	31	5	n/a
	Some primary school	44	7	
	Some secondary school	25	4	
	Years of schooling	n/a	16	3.9
Household size (# of people)	n/a	n/a	16	6.2
Land cultivated (hectares)	n/a	n/a	16	0.4

TABLE 2 | Results from quinoa taste trial at Total Landcare in Lilongwe ($N = 12$).

Gender	Would try again	Would not try again	Did not participate
Male	4	2	2
Female	2	1	1

RESULTS AND DISCUSSION

Collective Portrait of Interviewees

Twenty-one individuals were interviewed for this study: 16 individuals from eight villages near BCA and five change-agency personnel. **Table 1** provides descriptive statistics for the village interviewees. Seventy-five percent of the village interviewees were women. Among the female respondents, the majority lived in male-headed households. The youngest research participant was the daughter, aged between 17 and 22 years, of a widowed woman in Nkwinda Village. The oldest was a 60–65 years old widow in Kasisi Village. The average age of the village interviewees was approximately 40 years. Eleven of the village interviewees were married, and five were widowed. Five individuals had no schooling, while 11 had either some primary or secondary education. Average household size was six persons.

All research participants owned their own land. Total land area owned ranged from 0.1 to 2.5 hectares, with an average of 0.4 hectares (**Table 1**). A few village interviewees rented small plots for cultivation in addition to owning their own land. All village interviewees farmed rain-fed plots, and even if located near a water source, had no means of harnessing water for irrigation. Farm plots of village interviewees were reported to lay fallow during the dry season (after harvest). Fewer than half of the village interviewees also owned farm animals such as chickens, pigs, or cows. All village interviewees identified themselves as subsistence farmers; however, half of the interviewees reported working odd jobs to buy extra food, medicine, or clothing for their families.

Family members were the dominant source of farm labor. All respondents cultivated maize, the main staple food in the study area. However, 14 out of the 16 village respondents reported that they did not produce enough maize to meet their household requirements for an entire year. A higher proportion of female respondents reported producing inadequate quantities of maize to meet household needs compared with male respondents. Over half the households were depleted of food stocks by December. All village interviewees mentioned some kind of crop failure in the past couple of years. When asked about the reason for crop failures, 15 out of 16 village interviewees mentioned lack of fertilizer and inadequate rainfall.

Group Observation Results

Table 2 presents the results from the quinoa taste trial that took place at TLC in Lilongwe. Of the four female participants, two enjoyed the quinoa and would try it again. One woman did not enjoy the quinoa, and one woman left the quinoa on her plate (did not taste). Of the eight male participants, four said they enjoyed the quinoa and would try it again, two said they did not enjoy the taste, and two did not try the quinoa. All 12 participants ate the *nsima* on their plate first, before tasting the quinoa. The *nsima*, rather than forks or spoons, was used to scoop up the *ndiwo* (vegetable relish). All participants used their hands or the *nsima* to scoop up the other items on their plates. Because the quinoa was cooked as a rice and thus did not hold together firmly like the *nsima*, it was difficult to pick it up with one's hands and could not be used as a "scoop" for the *ndiwo*.

Significant differences in aroma, texture, taste, flavor, and processing characteristics have been identified across diverse quinoa varieties (Wu et al., 2014, 2017; Aluwi et al., 2016). Variety effects were described for taste and flavor (sweet, bitter, grain-like, nutty, earthy, and toasty); texture (firm, moist, cohesive, pasty, adhesive, crunchy, chewy, and astringent); and aroma (earthy, woody, buttery, grassy, and nutty) (Wu et al., 2017). Therefore, it is possible that participants in this study may prefer the taste, texture and/or aroma of a variety other than the one which they consumed. However, due to the lack of sufficient quinoa availability in Malawi at the time of the study, the quinoa used originated in South America, where the vast majority of quinoa is grown. Future studies pertaining to the adoption potential of quinoa in Malawi could focus on several locally grown varieties which are now available for cultivation and consumption (Maliro et al., 2017).

In addition, there exists considerable variation for α-amylase content and pasting viscosities (Aluwi et al., 2017). Therefore, similar to "sticky" or "glutinous" rice, appropriate quinoa varieties could be used to make it easier for eating with hands, similar to *nsima*, and using it as a scoop for the *ndiwo*. For example, the variety Temuco has been shown to possess a much lower final viscosity (147 mPa·s) than varieties Cahuil (343 mPa·s), Titicaca (361 mPa·s), Kaslaea (380 mPa·s), or Blanca (363 mPa·s), and would be an appropriate variety to test for this application (Aluwi et al., 2017). In another study, quinoa varieties "QQ74," "Linares," and "CO407D" were found to exhibit a particularly adhesive texture (Wu et al., 2017).

When asked, all participants preferred *nsima* to quinoa. Other feedback included suggestions for quinoa to be ground, and

perhaps mixed with *nsima*. One participant was interested to try quinoa prepared as a dessert, with sugar. Two participants noted that *nsima* is "our food" and "when we eat this [*nsima*] our stomach is okay." *Nsima* appears to be deeply tied to cultural and societal values. During meals *nsima* also functions as a vehicle to scoop other foods. Another participant described *nsima* as "fun" to eat, due to its malleable properties. When introducing a new food such as quinoa, characteristics such as texture and cooking time need to be evaluated along with integration into the sociocultural process of eating *nsima*.

Half of the participants in the group observation indicated they were open to trying quinoa again. All participants who responded well to quinoa suggested grinding quinoa into flour, so it can be mixed with maize flour to make *nsima*. This process of mixing flours to make *nsima* would make a newly introduced food more familiar and compatible with the lifestyles of the interviewees.

Evaluating Rogers' Compatibility

Compatibility With Values and Beliefs

Incompatibility of an innovation with sociocultural values and beliefs may hinder, delay or block the adoption of the innovation (Rogers, 2003). Our interview findings revealed that sociocultural values and beliefs were tied strongly to the production of maize and the preparation of the food staple, *nsima*.

All interviewees stated that maize is eaten at least two times a day, preferably three. *Nsima* patties are consumed mostly during lunch and dinner, with maize porridge predominantly consumed in the morning. Interviewees often had passionate responses when discussing maize and *nsima*. Interviewee #5 described *nsima* as the "food of the Malawi people." Some interviewees stated that if they have extra money from the sale of a chicken or pig, maize is the desired product to purchase at the market. Villagers often cheered when they heard *nsima* mentioned by the researchers. Interviewee #12 described the bland nature of *nsima*. However, when asked if he enjoyed *nsima*, he responded enthusiastically: "Of course! It is the food of Malawi!" When asked why everyone loves *nsima* so much, Interviewee #18 responded: "*Nsima* is not tasty. It's tradition. It's the thing you found when you are born. You are used to that food. If it is around 5 or 6 pm, and they [Malawians] haven't eaten *nsima* that day, they will say 'I haven't eaten today'."

Nsima is more than a staple food dish; it is a food associated with deep social and cultural pride. *Nsima* is considered the most important food eaten throughout the day. It is not only used as a utensil, but also considered a national symbol. The strong cultural ties Malawians have with *nsima* have the potential to influence the adoption of a new crop such as quinoa. However, all village interviewees expressed interest in trying new foods, as drought and crop damage from insects and disease had caused food shortages in recent years.

Compatibility With Previously Introduced Ideas

Compatibility of an innovation with a previously introduced idea can either hinder or increase the rate of adoption (Rogers, 2003). Previous negative experiences with a change agent or crop can have a negative impact on the way community members view a newly introduced crop or food. Of the 16 village interviewees, 12 had ongoing contact with BCA extension staff and EPA officers. These 12 individuals reported positive interactions with visiting extension agents. These previous interactions could have a significant impact on the potential adoption of an innovation such as quinoa. Village interviewees reported that their interactions with extension agents included the demonstration of more efficient planting practices, new ways of preparing food, and discussion of nutrition. Of the five extension workers interviewed, two were directly involved in meeting and interacting with villagers. They reported positive interactions with villagers and agreed that villagers seemed interested in their extension visits. Interviewee #21 stated: "The women we work with have a very good time learning about new recipes and new ways to cook. They are interested in providing better nutrition to their children."

A negative experience with a previously introduced innovation or idea can slow or prevent the adoption of future innovations. All 16 village interviewees responded with interest to the idea of a new crop to grow and eat, in addition to maize. The positive response to extension workers and the idea of a new crop or food may have the potential to increase compatibility with quinoa adoption. For example, an existing program within BCA's Home Economics and Human Nutrition Department has involved training women in nearby villages to process and prepare soybeans. This project has resulted in community education of soybeans' nutritional value and various other uses of soybeans for consumption in the region surrounding the BCA. This groundwork could potentially be used as a model for introducing quinoa to nearby villages.

Compatibility With Needs

One indicator of innovation compatibility is the extent to which an innovation addresses the felt needs of individuals or societal groups (Rogers, 2003). Although sometimes difficult to measure, needs can be assessed by interpersonal contact with potential adopters (Rogers, 2003).

To cope with food deficits, households reduce daily maize consumption (Denning et al., 2009). All village interviewees expressed an interest in the introduction of a new crop or food. Interviewee #6 stated: "We are very poor. And we would like any new food that can help us." When Interviewee #7 was asked about why she would like to try quinoa, she responded: "This year [2012] we had a poor harvest, and would like to try different crops that don't fail as much." Interviewee #12 said: "Any new food will help my family. We are very poor."

At the time of the interviews (July–August), approximately half of the interviewees were already making adjustments to their diet by not eating breakfast so maize supplies would last throughout the hungry season (typically beginning in December–January). This lack of food security indicates a need for supplemental crops in order for Malawians to obtain nutritious food throughout the extended hungry season.

Extent of Change Agents' Promotion Efforts

Evaluating Change Agent Effort

The degree of success of change agents is often "positively related to the extent of change agent effort in contacting clients" (Rogers, 2003, p. 373). Of the five change agents (i.e., extension agents and outreach personnel) interviewed, all mentioned the importance of having frequent interaction with clients (villagers) in order to achieve adoption success.

Interviewee #21 oversaw nutrition groups in the region surrounding BCA and visited villages for outreach purposes three to four times a week. She helped organize field days and demonstrations to show villagers how to process foods such as soybeans to diversify their diets.

When discussing her experience with soybean outreach to villages in the region, she explained that the rate at which adoption can occur depends on the amount of contact with extension personnel involved in introducing the innovation. She said: "The women in the village needed to be familiar with the food item [soybeans] and how to cook it. … Most people are used to eating *nsima*, so they feel that the new product you are introducing is not important. One of the ways we overcome the resistance is by using nutrition groups. We tell them that before they say something negative, to just try it first."

Nutrition groups were organized and led by Interviewee #21 in the region near BCA, and specific women were designated in each village to help other villagers with new innovations learned from the field days. These innovations ranged from how to pound soybeans into flour to prepare different foods, to teaching village children the different foods they can eat to stay healthy. Because the majority of villagers in this region are subsistence farmers, Interviewee #21 explained: "The farmers need to be able to see if the crop is successful. So adoption can be anywhere from 1 to 3 years." She stated that regular visits from extension workers are an important part of the adoption process. Interviewee #18 also expressed that change takes time and persistence. He stated: "Tradition is hard to change. People will do what they are used to. It takes time [to adopt something new]." With over 3 decades of experience in extension and outreach, Interviewee #20 said: "It takes 3–5 years for a farmer to adopt a new crop or idea. It takes time, and supervision and guidance."

There is robust involvement of women with farming and food activities in this region; nutrition groups and field days are well-attended by village women. Adoption of new innovations have been positively correlated with the amount of effort and time that the change agents with BCA and EPA outreach programs spend with villagers. With the potential introduction of a new food item such as quinoa, it would be advantageous to involve the EPA and BCA outreach programs in the region. Though crop diversity has contributed to dietary diversity in Malawi, other factors, including income, access to markets, education level, and availability of crop storage technologies had a greater impact on dietary diversity (Snapp and Fisher, 2015). In particular, educational opportunities and employment creation are needed for female head of households to improve dietary diversity (Snapp and Fisher, 2015).

Evaluating Compatibility With Clients' Needs

Successful adoption of an innovation is positively correlated with the degree a diffusion program is compatible to the needs of clients (Rogers, 2003). The five extension personnel interviewed all had knowledge of the social, environmental, and other problems of rural households in the area. Interviewee #18 worked with four farmers in the area to experiment with new crops and helped develop conservation agriculture methods. Because of shifting patterns in rainfall, and depleted nutrients in soils, extension personnel associated with the Malawian government, NGOs, and other organizations are working with villagers to practice conservation agriculture methods. When asked if farmers have benefitted from working with new methods of farming and new crops, Interviewee #18 stated: "We are introducing new things to them, and we have seen farmers continuing that. Farmers are now starting to grow that variety, because they see it growing well. If they see it growing with success, they are more likely to adopt it." He said these farmers are subsistence farmers, but if they have extra food from their farm, they will sell it for profit at market.

When asked about the main challenge associated with introducing something new, Interviewee #18 stated: "Even if you say it has a lot of nutrients, it doesn't matter. It is what fills you up that matters." Persistent problems facing poor households in central Malawi include hunger, malnutrition, and food insecurity (Simtowe et al., 2010). When asked about the benefit of promoting new food items, Interviewee #19 stated: "It [quinoa] is worth promoting so people can start using other foods to help with malnutrition." Interviewee #20 expressed the need for villagers to learn more about traditional fertilizers, such as animal manure and food scraps. He stated: "In my opinion we made a mistake when advocating for hybrid maize to reduce hunger. Hybrid maize uses a lot of chemical fertilizer. Now whole villages are dependent on purchasing fertilizer from stores." This was found to be consistent with many of the 16 village interviews performed. Of the 16 village interviewees, over half expressed the need for more nitrogen fertilizers from extension and outreach personnel.

Lunduka et al. (2012) found that the benefits of growing hybrid maize in Mulanje District, Malawi appear to be yield and drought tolerance, and there exists the possibility of an adoption plateau for these varieties in Malawi and across sub-Saharan Africa. When farmers select open pollinated, local landrace maize varieties, they prioritize and target traits such as early maturity, storability, poundability, taste, and flour-to-grain ratio. This suggests that if maize breeding programs in Malawi aim to break through the observed adoption plateau, it could be beneficial to select varieties that partially reflect farmer interest in a diversity of traits, in addition to grain yield and drought tolerance, that are valued by farmers. Farmers valued access to seeds, and diversity of varieties, with each variety particularly suited to a different suite of traits (Lunduka et al., 2012). Similar to research on the potential adoption of legumes in Malawi, which showed the importance of understanding socioeconomic factors and marketing concerns in addition to agronomic characteristics and farmer preferences (Waldman

et al., 2016), adoption of quinoa will be based on a wide range of agronomic and household criteria.

CONCLUSION

Drawing on in-depth interviews with 16 villagers and five change agents, as well as one group observation, this exploratory study evaluated the adoption potential of a food innovation (quinoa) and the diffusion of information between extension programs and local farmers in central Malawi. We focused on perceived compatibility (an innovation attribute) and change agents' promotion efforts, both of which play important roles in the Diffusion of Innovations framework (Rogers, 2003). The Diffusion of Innovations framework proved useful in organizing and analyzing our data because of its emphasis on sociocultural values and beliefs, awareness of clients' needs, and importance of change agents' (extension agents') communication and rapport with potential adopters.

Interview results confirmed a strong motivation to add new foods to the current Malawian diet despite sociocultural barriers such as the national affection for *nsima*. Interviewees' apparent willingness to consider new foods as an addition to the traditional diet is a positive sign for the potential future adoption of quinoa.

The network of extension personnel in the study region could be an extremely valuable asset to the adoption of an innovation such as quinoa. Village interviews revealed positive past experiences with extension personnel visits. The BCA and EPA presence in the region could be a vehicle for future food introductions and education. Participatory work with both villagers and extension agents in central Malawi could help promote quinoa as a new food innovation. The involvement of women, in particular, when introducing a new innovation such as quinoa may be key in its acceptance as a new food in the region.

Perhaps our most important research finding was the request from villagers and extension personnel to grind quinoa into a flour and prepare it in a dish similar to, or mixed with, *nsima* (derived from maize). *Nsima* is typically picked up by hand and used as a utensil to scoop up other foods on the plate. Group observation participants believed that quinoa cooked and served similar to rice was difficult to pick up and use as a utensil. The willingness of many Malawians in this region to try quinoa as flour may be key to its acceptance. In addition, varieties of quinoa with different pasting and viscosity characteristics could be used to increase the stickiness of cooked quinoa.

Future research is needed to fully evaluate the potential adoption of quinoa for consumption in central Malawi. As mentioned by participants in the group observation, a food taste trial would be valuable in testing quinoa flour mixed with maize flour to make *nsima.* A side-by-side comparison of maize and quinoa preparation would be valuable for estimating preparation times. Participatory research with BCA and EPA structured and designed with the purpose of program implementation of quinoa education strategies, similar to past educational outreach focused on soybeans, would be an important step in understanding the potential adoption of quinoa. Outreach resources in this region are extensive, and are a valuable asset when bridging the gap between researchers, change agents, and villagers. Also, while this study focused on quinoa as a food source, future outreach personnel and researchers should consider presenting quinoa as a potential crop due to the high prevalence of subsistence farming in this region. Finally, it will be important to conduct a similar study to this exploratory research, where we incorporate the ideas above with a significantly larger and more regionally representative group of farmers, villagers, and change agents. Growing quinoa as a local crop is the most logical way to obtain and eventually consume the new food and incorporate it into the local diet.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

Based on the Exemption Determination Application submitted for the study titled The social acceptability of quinoa as a supplement in the Malawian diet, and assigned IRB # 12630, the Washington State University Office of Research Assurances determined that the study satisfies the criteria for Exempt Research at 45 CFR 46.101(b)(2) and 45 CFR 46.101(b)(6), and therefore, that this study may be conducted according to the protocol described in the Application without further review by the IRB. Written informed consent was not obtained because it was determined that the majority of study participants were unable to read or write. Verbal consent was provided for the publication of all the information except for age of the individual. Therefore, ages of an individual presented in this manuscript were done so using a 5-year age range.

AUTHOR CONTRIBUTIONS

All authors collaborated to conceive different aspects of the research. MG and MM conducted the research in Malawi. MG wrote the manuscript. MM, JG, and KM contributed to the writing and also edited the manuscript.

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